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ORIGINAL ARTICLES.

I.—The Jordan-Arabah Depression and the Dead Sea.

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THE following account of the geology of the Dead Sea basin has been compiled from the observations of others, and I am especially indebted in this connection to H. J. Johnson, Geologist of the United States Expedition to the Dead Sea,[1] to Professor Louis Lartet, Geologist of the Duc de Luynes' Expedition to the same region,[2] and to Prof. Edward Hull, F.R.S., Director of the Geological Survey of Ireland, who visited Arabia Petræa and Palestine in 1883–84, under the auspices of the Committee of the Palestine Exploration Fund.[3] Besides these observers, who devoted their attention specially to the geology of the regions traversed during

[1] This Expedition visited Palestine in 1848, under direction of Lieut. W. S. Lynch. Among its more important contributions to science was the measurement, by means of the spirit level, of the depression of the surface of the Dead Sea below the level of the Mediterranean, the exploration of the River Jordan from the Sea of Galilee to its mouth, and the determination, by sounding, of the depth of the Dead Sea. The results of this Expedition were published in "Official Report of the United States Expedition to the Dead Sea and the River Jordan," by Lieut. F. W. Lynch, U.S.N., Baltimore, 1852; 4to. pp. 1–236, pl. 17, and a map. Also in "Narrative of the United States Expedition to the Dead Sea," by F. W. Lynch, U.S.N., Philadelphia, 1849; 8vo. pp. i–xx, 1–508, pl. 28, and two maps.

[2] This Expedition, fitted out and directed by the Duc de Luynes, visited Palestine and the adjacent regions in 1864; its scientific results include important contributions to geology and palæontology, and a study of the chemistry of the waters of the Dead Sea. Preliminary publications of the results of Louis Lartet's observations while connected with this Expedition, appeared in the "Annales des Sciences Géologiques" for 1869 and 1872. The final report is: "Voyage d'Exploration à la Mer Morte," par M. le Duc de Luynes, Tome Troisième, "Géologie" (Paris, 1877), 4to. pp. i–vi, 1–326, pl. 1–14.

[3] The report of the geological observations made during this Expedition has recently appeared, and is an important and highly interesting contribution to geological science. Its title is: "Memoir on the Geology and Geography of Arabia Petræa, Palestine, and adjoining districts." Published for the Committee of the Palestine Exploration Fund, London [?], 1886. 4to. pp. i–viii, 1–145, pl. 3, and three maps. A narrative of this expedition by the same author, scarcely less important than the final report, is entitled: "Mount Seir, Sinai, and Western Palestine, being a narrative of a scientific expedition," 1883–84, London, 1885. 8vo. pp. i–vi, 1–227, pl. 1–13, and two maps.

their several expeditions, the writer is under obligations to the Ordnance Survey of Palestine, and to many observant travellers, including Condor, Fraas, Tristram, Wilson, and others, for many interesting details and attractive descriptions concerning the regions to which it is desired to direct the reader's attention.

The similarity between the recent geological history of the Dead Sea, and the area of interior drainage in America known as the "Great Basin," with which I have some familiarity, is so marked that I venture to offer a few suggestions and hypotheses, which will, perhaps, be of interest to those who may continue the study of the Geology of Palestine and adjacent regions. I have also inserted a brief account of certain lake-shore phenomena, which have proved of great value in interpreting the ancient histories of several American lakes, which are comparable in many ways with the Dead Sea.

Physical Geology of the Dead Sea Region.

On the west side of the abrupt valley in which the Sea of Galilee, the valley of the Jordan, the Dead Sea, and the Wady Arabah—termed the Jordan-Arabah depression—are situated, lies the table land of Judæa, and the extension southward of the same physical feature known as the plateau of the Tih. The general elevation of this extensive table land is about 2000 feet above the Mediterranean, with occasional eminences attaining a height of from 2500 to 3000 feet. On the east it breaks off in an abrupt escarpment, which forms the western boundary of the Jordan-Arabah depression. This depression is bounded on the east by an escarpment still more rugged and of a greater elevation than on the west. The eastern wall, like the western, exposes the edges of strata which form a vast plateau, known east of the Jordan as the table land of Moab, having a general surface level of about 3000 feet, and farther south as the table land of Edom, the general elevation of which is about 4000 feet above the ocean. The Moab-Edom plateau stretches far to the eastward, with but little change in its physical features, and merges with the Syrian and Arabian deserts, but is not again broken by a sunken area similar to that holding the Dead Sea.

The depression separating the plateaux we have mentioned is from five to nine miles broad, and extends in an approximately north and south direction from the base of Mount Hermon at the north to the Red Sea at the south, a distance of fully 375 miles. Its southern end is occupied for about 100 miles by the waters of the Gulf of Akabah. The length of the Jordan-Arabah depression proper is nearly 250 miles, its southern terminus being at the watershed between the Wady Arabah and the drainage which finds its way toward the Gulf of Akabah.

Considering general features simply, there are two elevated table lands in the south-western part of Asia Minor, separated by a deep, narrow depression or fault valley, which is partially filled by the Dead Sea.

Origin of the Jordan-Arabah Depression.

The observations of Hull, Lartet, Tristram, and others, have shown that this depression has been produced by a fault. In other words, it is due to a fracture in the rocks forming the adjacent table lands, accompanied by a subsidence of the strata on the west side of the fracture in relation to the broken edges of the corresponding beds on the east. The amount of this displacement is not accurately known, and no doubt varies at different portions of the fault line, but is certainly several thousand feet. Judging from the sections published by Hull, 5000 or 6000 feet would be a reasonable minimum estimate. This great fracture follows the base of the escarpment bordering the Jordan-Arabah depression on the east, and passes beneath the Dead Sea near its eastern shore. Its full linear extent is not known, but it has been traced by Hull and others for perhaps 150 miles. Its course is somewhat irregular, and numerous branches or secondary faults are connected with it, but its general bearing throughout its entire course is a few degrees east of north. The hade of the fault plane has not been definitely determined at any locality so far as we can ascertain, but is represented in sections published by various geologists as dipping toward the thrown block at a high angle; that is, it is considered as a normal fault, in distinction from reversed faults, in which the hade is toward the upthrow.

The strata composing the plateaux adjacent to the Dead Sea fault have been but little disturbed except in proximity to the line of fracture, and over large areas are nearly horizontal. The rocks forming these plateaux are Cretaceous limestones and sandstones, resting on rocks of the Carboniferous system, which in their turn are underlain by metamorphic strata perhaps of Archean age, together with igneous rocks of ancient but unknown date. Besides these older formations there are, especially in the neighbourhood of the Sea of Galilee, volcanic dykes and overflows of basaltic lava that are geologically recent.

The formation of the Jordan-Arabah depression, although due to a violent fracturing of the earth's crust, cannot be considered as having been formed suddenly at a single great catastrophe, but, judging from what we know of the formation of similar faults in other regions, must have been of slow growth, accompanied by many earthquakes, and may perhaps be still increasing its displacement. The numerous earth tremors felt in Palestine during the present century may possibly owe their origin to slight slips along this line of fracture.

Lakes in the Dead Sea Basin.

The lacustrine history of the Dead Sea basin began with the time when the fault to which it owes its origin had gained sufficient dimensions to interrupt the previous drainage of the region. This statement is made on the supposition, in the absence of evidence to the contrary, that the south-western part of Asia Minor was a land surface at the time the fault was initiated.

The date of the beginning of this independent drainage system is not definitely known. It was post-Cretaceous, for the reason that Cretaceous rocks form its walls. That it existed as a prominent topographic feature previous to the Glacial epoch is shown by its lacustrine records, taken in connection with the history of adjacent regions during the Quaternary period. Its birth must therefore have been during the Tertiary period.[1]

The best estimate that can be made at present of the extent of the hydrographic basin of the Dead Sea shows that it occupies an area of between nine and ten thousand square miles. The Dead Sea is about 274 square miles in extent.[2] Consequently the ratio of lake surface to drainage area is about as one to thirty-three. The lowest point in the basin is depressed 2570 feet below the level of the Mediterranean, and the lowest point on its rim is 285 feet above the same datum plain, or 1577 feet above the surface of the Dead Sea. It is evident from the present topography that this hydrographic basin must have held a lake in its lowest depression, either continuously or at intervals during humid periods, ever since it was cut off from oceanic drainage.

A lake occupying the Jordan-Arabah depression, like all inclosed lakes, must have been sensitive to climatic changes, and could its past fluctuations be determined in terms of climate, they would furnish a geological weather record of unusual value. In illustration of this it may be observed that as the present arid climate of the Dead Sea basin admits of the existence of a large lake in its lowest depression, it follows that only during periods of excessive aridity could the ratio of evaporation to precipitation be increased sufficiently to cause the lake to disappear. If we could show, therefore, that the Dead Sea was evaporated to dryness, or was greatly concentrated, at any period in its history, we should have proof of the former prevalence of an unusually arid climate in Palestine and adjacent regions. On the other hand, could we show that the Dead Sea once had a much greater expansion than at present, it would be conclusive evidence of a former period of greater mean humidity than the region about it now enjoys.

The fact that the Dead Sea basin has been long isolated is in itself sufficient to suggest that it has an interesting and perhaps highly complex lacustrine history. Fortunately, however, we have observation as well as hypotheses to help us in this connection. From the reports of many explorers we know that the shores of the Dead Sea and the borders of the Jordan valley are scored with terraces, and that lacustrine sediments, in some cases charged with the shells of fresh water mollusks and at other times interlaminated with layers of salt and gypsum, are found over a very large area. Sufficient facts of this nature have been reported by competent observers to show that the Dead Sea basin has a record

[1] Hull places it at the close of the Eocene. Geol. and Geog. of Arabia Petræa, Palestine, etc., p. 108.

[2] Determined from the map accompanying the narrative of the U.S. Expedition. The mean depth of the Dead Sea as obtained from the same map is 500 feet.

of unusual interest inscribed on its walls, much of which is written in such bold characters that he who runs may read.

Before considering the facts that are available in reference to the former climatic condition of Palestine, and the deductions which legitimately flow from them, let us glance briefly at the nature of the records to be looked for, in order to interpret the lacustrine history of an inclosed drainage area of the nature of the Dead Sea basin.

Lacustrine Records.

Sea-Cliffs.—Waves breaking along a shore tend to undercut it and allow the material forming the land to fall from above. This process, as may be seen on every shore, produces a slope, more or less abrupt, which is termed a sea-cliff. The steepness of such slopes depends on the rate of cutting and on the nature of the material removed. When the work of the waves is rapid, and the shores are formed of material having a high angle of stability, perpendicular, or even over-hanging cliffs are produced. When the wave erosion at the base is less rapid than the atmospheric erosion at the top of a cliff, the slope is less abrupt. The height of cliffs produced in this manner varies from a few feet, or even a few inches, up to many hundred feet. Their bases are horizontal, and at the water line the rock is frequently eaten away irregularly, so as to form caves.

Terraces.—Waves and currents in cutting away the shores which confine them, remove the material brought within their reach, and as their work progresses landward, form a horizontal shelf or terrace. Such a terrace is bordered on the landward side by a sea-cliff which rises above it, and on the lakeward side by a downward slope, which is usually covered to some extent with debris, derived from the formation of the terrace itself. Terraces of this description are horizontal along the line where the shelf joins the sea-cliff, and slope from this line gently lakeward. When seen in profile, they appear as a notch more or less strongly defined on the slope confining the lake.

Terraces frequently occur at many horizons on the shores of inclosed basins; their relative strength, other things being equal, being determined by the length of time the water lingered at each horizon. When the waters of a lake are withdrawn or greatly lowered, the records of their former levels appear from a distance especially when the shores are steep, as horizontal parallel lines, drawn on the borders of the basin. These lines follow all the irregularities and sinuosities of the shore, and are usually strongest and best defined on promontories and on coasts facing a broad water area. At the heads of sheltered bays, even in the case of lakes of great size, both terraces and sea cliffs are sometimes absent.

A terrace of excavation, the formation of which we have just described, marks definitely the outline of the water surface to which it owes its origin. By following such a terrace one can ascertain if it was ever broken by a channel of overflow, and thus in the case of a desiccated lake basin, determine one of the most important points

in its history. As a terrace when formed is level—with certain slight variations due mainly to the action of the wind in heaping up waters in bays, etc.—a measurement of its present relation to a horizontal plain will indicate whether or not it has been deformed by orographic movement.

The terraces described in the preceding paragraph are terraces of excavation. In nature we find terraces of construction as well. These are formed of the debris cut away from the shore by waves and currents, and spread out as a belt of shingle along the shore, resting usually on a cut terrace. The combination of cut and built terraces is the most common of lake-shore records, and the most easily identified in abandoned lake-basins.

The material removed from the shores of a lake during the cutting of its marginal terraces, together with much of the debris contributed from the land by streams, is removed more or less completely, and after being assorted by the action of waves and currents, is variously distributed. The finer portions remain in suspension for a considerable time, and may be carried away from the land, and on subsiding contribute to the sedimentation of the basin. The coarser portions consisting of sand, gravel and boulders, are too heavy to be floated, and therefore remain in close proximity to the shore. This material is swept along the lake margin by currents, and finally built into beaches, barriers and embankments.

Beaches.—In the formation of beaches the shore debris remains at the lake margin and may coincide with a built terrace, as previously noted, or form a terrace along a shore where no excavation has taken place. In either instance the material composing the beach, usually gravel, is in motion, especially during storms, and is being carried forward to where barriers and embankments are forming.

Barriers.—On lake margins of gentle declivity ridges of gravel and sand are formed at some distance from the shore, but connected at their extremities with terraces or beaches from which the material for their construction is derived. The surfaces of such ridges are horizontal and coincide with the storm limit of the waves and currents to which they owe their origin. They follow the broader sweeps of lake margins but not minor irregularities, and in desiccated lake basins appear like railway embankments. They frequently close the mouths of bays so as to shut them off from communication with the main water body, thus forming lagoons.

Embankments.—When the combined action of waves and currents extends a barrier into deep water, an embankment is formed, which in many cases becomes of very grand proportions. In the formation of embankments the debris of which they are composed is swept along the surface of the barrier or terrace leading to them, and deposited when deep water is reached. This process continues until the embankment has been built up to the water surface. It is then prolonged by material carried along its crest and deposited at its distal extremity. Both bars and embankments, when seen in cross section, having a more or less well-defined anticlinal structure. An arch of this character is termed an "anticlinal of deposition." The

elevations of the horizontal surfaces of barriers and embankments, in the case of fossil lakes, furnish the most accurate of all shore records for determining former water levels.

Deltas.—A delta formed by a high grade stream, when seen in section, presents a well-marked tripartite structure. The middle member consists of water-worn gravel, more or less thoroughly assorted, in layers sloping lakeward at an angle corresponding with its angle of stability in water. The thickness of this deposit increases as the delta is advanced, and in lakes with precipitous borders may become several hundred feet deep near the lakeward margin. Beneath the inclined gravels, especially in the case of deltas that have been prolonged some distance into a lake, are lacustrine clays and marls, which are usually crumpled and otherwise deformed, owing to the weight of the mass of material superimposed upon them. Above the inclined gravel is a deposit of unassorted or irregularly assorted debris, which is thinnest toward the periphery of the delta and thickest towards its apex. The history of the growth of a delta may be inferred from its structure, and need not be described here.

We have not attempted even a sketch of all the features of lake shores that are of assistance to the geologist in determining the history of a fossil lake, partially for want of space, but principally for the reason that an exhaustive analysis of lake-shore phenomena is already accessible to the student.[1]

Mechanical Sediments and Chemical Precipitates.—The deposits usually formed in lakes, as is well known, are evenly stratified clays and marls, which are in many instances charged with shells. When lakes are without outlet, however, and become saline owing to the concentration of their water by evaporation, their faunas are exterminated or greatly modified, and the mineral matter held in solution is precipitated when the process has progressed sufficiently. If concentration continues without interruption, there will be a regular sequence in the precipitates formed, beginning under normal conditions, with calcium carbonate, followed by calcium sulphate, sodium chloride and other salts.

Chemical precipitates originating in the manner mentioned above may be deposited on the sides of a lake basin with rocks and stones for nuclei, as is the case very commonly with incrustations of calcareous tufa; or they may be precipitated generally over the lake bottom and become mingled with clays and marls deposited simultaneously. When sedimentation is taking place but slowly, layers of various salts may attain a depth of many feet, and should uniform conditions continue, may even become hundreds of feet in thickness. After the precipitation of saline deposits of this nature a lake might expand owing to a climatic change and be freshened either on account of the increase in supply, or by the waters rising sufficiently to find an outlet, and thus flood out the previously concentrated brine. In such instances the beds of calcareous tufa, gypsum and common

[1] "The Topographic Features of Lake Shores," by G. K. Gilbert, in Fifth Annual Report of the U. S. Geological Survey, 1883-84, Washington, 1885.

salt precipitated during the period of concentration, might become buried beneath layers of marl and clay abounding in the remains of mollusks and fishes.

With this imperfect lesson on what is taking place in lakes at the present day, let us return to the Dead Sea.

(*To be concluded in our next Number.*)

II.—Woodwardian Museum Notes. On a Specimen of *Cyclopteris* (Brongniart.)

By Albert C. Seward, B.A., F.G.S.,
Foundation Scholar of St. John's College, Cambridge.

(PLATE X.)

THE specimen of which I give below a brief description is of some interest as adding to the store of facts which may help us in the elucidation of the obscure genus *Cyclopteris*. So far as I know such large *Cyclopteris* leaves have not been previously figured attached to a rachis.

The described specimen, which I have placed in the Woodwardian Museum, was given to me by Mr. Walter Hemingway, of Barnsley, who found it in the Upper Coal-measures of Brierly Common, Yorkshire. When first seen[1] the rachis was 4ft. 2in. long, and had five pairs of pinnules, the distance between each pair decreasing towards the thinner end of the rachis. Unfortunately it was impossible to get the fossil out whole, only two pairs of pinnules being obtained in a perfect state.

Frond pinnate. Pinnules suborbicular; sessile; apparently lobed at the base, the lobes resting on the rachis: the lower margin of the pinnules is somewhat abruptly cut off as if the present shape might be due to tearing or imperfect preservation, the original pinnule having probably a more rounded or tapering base. No midrib, the nervures radiate from the basal portion of the pinnules and frequently dichotomise as they proceed towards the margin, where they are delicate and numerous.

The rachis is represented by a raised portion of the stone, which is finely striated longitudinally, the striæ being somewhat irregular, and not continuous from one end to the other: a few isolated fragments of carbanaceous matter represent the original cortical tissues of the rachis.

Length of rachis shown in figure 8 cm.; breadth 2 cm.; pinnules in longest part 7 cm.; greatest breadth 5 cm.

The genus *Cyclopteris* established by Brongniart in 1828, is defined by him as follows:[2]—"Fronde simple, entière, le plus souvent orbiculaire ou réniforme; nervures nombreuses toutes égales, dichotomes, rayonnant de la base." The essential generic characters being the absence of a midrib, and the basal origin of the nervures. In the "Histoire des végétaux fossiles"[3] Brongniart figures several

[1] I am indebted to Mr. Hemingway for these facts.
[2] Prodrome d'une hist. des végét. foss. p. 51 (1828).
[3] Hist. des végét. foss. plates 61 and 61 bis. (1828–1837).

Cyclopteris (Binney).

species of *Cyclopteris*, none of which exactly correspond to my specimen. *Cyclopteris obliqua*, which is represented as an isolated petiole, being the most like it. In his later work[1] Brongniart divides the Cyclopteroid forms into two genera, *Cyclopteris* and *Nephropteris*: the former he defines as follows:—"Fronde simple, pédicellée, symétrique, arrondie, cordiforme, ou flabellée, entière ou lobée, sans apparence de nervure médiane, toutes les nervures partant de la base du limbe, et se divisant en se dichotomant pour atteindre la circonférence."

Cyclopteris reniformis, C. trichomanoides, C. digitata, etc., belong to this genus.

The genus *Nephropteris* which is thus defined:—"Frondes isolées, simples, sessiles, obliques, non symétriques, arrondies ou cordiformes, ordinairement concaves et ombiliquées à leur base"—includes such forms as *Cyclopteris obliqua, C. oblata, C. orbicularis*, etc. These species are regarded by Brongniart as a distinct group; he considers them to be anomalous basal leaves, referable probably to the genera *Neuropteris* and *Odontopteris*.

Lindley and Hutton[2] give two figures of *Cyclopteris obliqua*; they point out that the absence of any stalk and the trace of what seems to them a distinct disarticulation favour the idea that the specimens originally formed parts of compound leaves. This being the case, they consider them referable to *Neuropteris* rather than *Cyclopteris*.

It is also suggested by these authors[3] that *Neuropteris ingens* may have belonged to the same plant as *Cyclopteris obliqua*.

In the "Illustrations of Fossil Plants," edited by Prof. Lebour,[4] there is a figure of *Cyclopteris* (*Nephropteris*) *obliqua* which shows two pinnules attached to a rachis; this specimen closely resembles the one I have figured, except in its much smaller size.

In his earlier writings Lesquereux[5] retains the genus *Cyclopteris*, and considers that all Cyclopteroid leaves attached to stems form a distinct genus: those without stems and with arched nervures are included in *Neuropteris*, those without stems and with straight and diverging nervures are classed with *Odontopteris*. The Cyclopteroid leaves with stems are retained in the genus *Cyclopteris*, which is subdivided into three sections:—(*a*) Adianthoides. (*β*) Odontopteroides. (*γ*) Neuropteroides.

In the description of fossil plants in the Report of the Geological Survey of Illinois, Lesquereux[6] no longer regards *Cyclopteris* as a distinct genus, further evidence having been obtained in favour of the connection of *Neuropteris* and *Cyclopteris*. *Neuropteris* is defined so as include leaflets without a median nervure.

[1] Tableau des genres de végét. foss., considérés sous le point de vue de leur classification botanique et de leur distribution gélogique, p. 16 (1849).
[2] Fossil Flora, pl. 90 (1831-1837).
[3] Fossil Flora, vol. ii. p. 28.
[4] Illust. of Fossil Plants, p. 23, pl. 11.
[5] Description of Fossil Plants in Geology of Pennsylvania, by H. D. Rogers, vol. ii. (1858).
[6] Description of Fossil Plants in Report Geol. Survey of Illinois, vol. ii. p. 427 (1866).

In the Palæontographica for 1868–69,[1] Roehl figures a large specimen showing *Neuropteris Loshii* and *Cyclopteris trichomanoides* on the same rachis. In his description of *Neuropteris Loshii* he remarks :[2]—"On the axis or a very large frond I found *Cyclopteris trichomanoides* (Brongt.), which hitherto had only been found by itself, grown as axial leaves ('Spindelblätter') of this plant." The Cyclopteroid leaves are in this case only attached to one side of the rachis: the size and striated character of the rachis closely connect it with my specimen. Schimper[3] figures some examples under the name of *Cardiopteris frondosa* (Göpp.), showing large pinnules attached to a rachis: the nervation and the comparatively equilateral form of these pinnules resemble Neuropteroid rather than Cyclopteroid leaves, of which latter mine is an example. Feistmantel,[4] in describing the genus *Cyclopteris*, points out that if it is established that many of the species of *Cyclopteris* are basal or axial leaves ("Basal—oder Spindel—blättchen") of *Neuropteris*, other species have the characteristics of *Cyclopteris* as defined by Brongniart, viz. absence of a median nervure, and the dichotomous and flabellate character of the nervures which spring from the base of the pinnules. The figures[5] given by Feistmantel of Göppert's *Cyclopteris polymorpha* show the pinnules attached to a rachis, but the nervures appear to start from the centre of the base as they do in *Cardiopteris frondosa* (Göpp.).

Grand'Eury[6] refers some specimens of *Cyclopteris* to *Neuropteris*, and others to *Odontopteris*; he considers *Cyclopteris obliqua* and *C. oblata* to be merely detached pinnules of *Neuropteris*.

Mr. Kidston,[7] in his catalogue of Palæozoic plants in the British Museum, goes so far as to drop the genus *Cyclopteris* entirely; he considers *Cyclopteris dilatata, C. obliqua*, etc., to belong to *Neuropteris heterophylla* and refers to Roehl's figure in support of this view. He points out how the pinnules of *Neuropteris Scheuchzeri* (Hoff.) vary in form, some being the typical acute forms and others belonging to the Cyclopteroid type. The shape of the pinnules varies so much that it is of no specific value. In the absence of such evidence as is afforded by fructification, we must rely to a great extent on the arrangement of the nervures. In my specimen the pinnules appear to be almost opposite on the rachis, but this is of no great importance, as Mr. Kidston remarks,[8] "the alternate or opposite arrangement of pinnæ or pinnules appears to be a character of little value, as they are frequently alternate and opposite on different parts of the same frond."

Through the kindness of Prof. Lebour and Mr. Howse I was allowed to examine the Hutton collection of plants in the Newcastle Museum; in this collection there is a specimen showing a pinnule

[1] Palæontographica, vol. xviii. taf. xvii.
[2] *Ibid.* p. 37.
[3] Traité de Pal. végét. pl. xxxv. (1869–74).
[4] Zeitsch. der Deutsch. Geolog. Gesell. Band xxi. p. 521.
[5] *Ibid.* taf. xvi. figs. 21–24.
[6] Flore Carb. du Depart. de la Loire, etc. p. 379 (1877).
[7] Catalogue of the Pal. Plants in the British Museum, p. 90 (1886).
[8] *Ibid.* p. 84.

of *Cyclopteris obliqua* attached to a thick rachis 23 cm. in length, the pinnule is not perfectly preserved, and there are no signs of a corresponding one on the other side; the rachis is of similar appearance to the one in my specimen.

In the present state of our knowledge it would be premature to speak positively as to the claims of *Cyclopteris* to be considered a distinct form, the specimen before us, however, seems to justify our retaining for the present Brongniart's original genus.

III.—Recent Observations on the Glaciation of British Columbia and Adjacent Regions.

By Geo. M. Dawson, D.Sc., F.G.S.,
Assistant Director, Geological Survey of Canada.

PREVIOUS observations in British Columbia[1] have shown that at one stage in the Glacial period—that of maximum glaciation—a great confluent ice-mass has occupied the region which may be named the Interior Plateau, between the Coast Mountains and Gold and Rocky Mountain Ranges. From the 55th to the 49th parallel this great glacier has left traces of its general southward or south-eastward movement, which are distinct from those of subsequent local glaciers. The southern extensions or terminations of this confluent glacier, in Washington and Idaho Territories, have quite recently been examined by Mr. Bailley Willis and Prof. T. C. Chamberlin, of the U.S. Geological Survey.[2] There is, further, evidence to show that this inland-ice flowed also, by transverse valleys and gaps, across the Coast Range, and that the fiords of the coast were thus deeply filled with glacier-ice which, supplemented by that originating on the Coast Range itself, buried the entire great valley which separates Vancouver Island from the mainland and discharged seaward round both ends of the island. Further north, the glacier extending from the mainland coast touched the northern shores of the Queen Charlotte Islands. The observed facts on which these general statements are based have been fully detailed in the publications already referred to, and it is not the object of this note to review former work in the region further than to enumerate the main features developed by it, and to add to these a summary of observations made during the summer of 1887 in the extreme north of British Columbia, and in the Yukon basin beyond the 60th parallel, which forms the northern boundary of that province.

The littoral of the south-eastern part or "coast strip" of Alaska presents features identical with those of the previously examined coast of British Columbia, at least as far north as lat. 59°, beyond which I have not seen it. The coast archipelago has has evidently been involved in the border of a confluent glacier which spread from the mainland and was subject to minor variations

[1] Quart. Journ. Geol. Soc. vol. xxxi. p. 89. *Ibid.* vol. xxxiv. p. 272. Canadian Naturalist, vol. viii.

[2] Bulletin U.S. Geol. Survey, No. 40, 1887.

in direction of flow dependent on surface irregularities, in the manner described in my report on the northern part of Vancouver Island.[1] No conclusive evidence was here found, however, either in the valley of the Stikine River or in the pass leading inland from the head of Lynn Canal, to show that the ice moved seaward across the Coast Range, though analogy with the coast to the south favours the belief that it may have done so. The front of the glacier must have passed the outer border of the Archipelago, as at Sitka, well-marked glaciation is found pointing toward the open Pacific[2] (average direction about S. 81° W. astr.). It is, however, in the interior region, between the Coast Range and the Rocky Mountains proper and extending northward to lat. 63°, explored and examined by us in 1887, that the most interesting facts have come to light respecting the direction of movement of the Cordilleran glacier. Here, in the valleys of the Pelly and Lewes branches of the Yukon, traces were found of the movement of heavy glacier-ice in a northerly direction. Rock-surfaces thus glaciated were observed down the Pelly to the point at which it crosses the 136th meridian and on the Lewes as far north as lat. 61° 40′, the main direction in the first-named valley being north-west, in the second north-north-west. The points referred to are not, however, spoken of as limiting ones, for rock exposures suitable for the preservation of glaciation are rather infrequent on the lower portions of both rivers and more extended examination may result in carrying evidence of the same kind much further toward the less elevated plains of the Lower Yukon. Neither the Pelly valley nor that of the Lewes is hemmed in by high mountainous country except toward the sources, and while local variations in direction of the kind previously referred to are met with, the glaciation is not susceptible of explanation by merely local agents, but rather implies the passage of a confluent or more or less connected glacier over the region.

In the Lewes valley, both the sides and summits of rocky hills 300 feet above the water were found to be heavily glaciated, the direction on the summit being that of the main (north-north-west) orographic valleys, while that at lower levels in the same vicinity followed more nearly the immediate valley of the river, which here turns locally to the east of north.

Glaciation was also noted in several places in the more mountainous country to the south of the Yukon basin, in the Dease and Liard valleys, but the direction of movement of the ice could not be determined satisfactorily, and the influence of local action is there less certainly eliminated.

Of the glacial deposits with which the greater part of the area of the inland region is mantled, it is not intended here to give any details, though it may be mentioned that true Boulder-clay is frequently seen in the river-sections, and that this generally passes upward into, and is covered by, important silty beds, analogous to

[1] Annual Report Geol. Surv. Canada, 1885, p. 100 B.

[2] Mr. G. F. Wright has already given similar general statements with regard to this part of the Coast of Alaska, American Naturalist, March, 1887.

the silts of the Nechacco basin, further south in British Columbia, and to those of the Peace River Country to the east of the Rocky Mountains. It may be stated also that the country is generally terraced to a height of 4000 feet or more, while on an isolated mountain-top near the height of land between the Liard and Pelly rivers (Pacific-Arctic watershed) rolled gravel of varied origin was found at a height of 4300 feet, a height exceeding that of the actual watershed by over 1000 feet.

Reverting to the statements made as to the direction of the general glaciation, the examination of this northern region may now be considered to have established that the main gathering-ground or *névé* of the great Cordilleran glacier of the west coast, was included between the 55th and 59th parallels of latitude in a region which, so far as explored, has proved to be of an exceptionally mountainous character. It would further appear that this great glacier extended, between the Coast Range and the Rocky Mountains, south-eastward nearly to lat. 48°, and north-westward to lat. 63°, or beyond, while sending also swollen streams to the Pacific Coast.

In connection with the northerly direction of ice-flow here mentioned, it is interesting to recall the observations which I have collected in a recently published report of the Geological Survey, relating to the northern portion of the continent east of the Mackenzie River.[1] It is there stated that for the Arctic coast of the Continent, and the Islands of the Archipelago off it, there is a considerable volume of evidence to show that the main direction of movement of erratics was *northward*. The most striking facts are those derived from Prof. S. Haughton's Appendix to M'Clintock's Voyage, where the occurrence is described of boulders and pebbles from North Somerset, at localities 100 and 135 miles north-eastward and north-westward from their supposed points of origin. Prof. Haughton also states that the east side of King-William's Land is strewn with boulders of gneiss like that of Montreal Island, to the southward, and points out the general northward ice-movement thus indicated, referring the carriage of the boulders to floating-ice of the Glacial Period.

The copper said to be picked up in large masses by the Eskimo, near Princess-Royal Island, in Prince-of-Wales Strait, as well as on Prince-of-Wales Island,[2] has likewise, in all probability been derived from the copper-bearing rocks of the Coppermine River region to the south, as this metal can scarcely be supposed to occur in place in the region of horizontal limestone where it is found.

Dr. A. Armstrong, Surgeon and Naturalist to the "Investigator," notes the occurrence of granitic and other crystalline rocks not only on the south shore of Baring Land, but also on the hills at some distance from the shore. These, from what is now known of the region, must be supposed to have come from the continental land to the southward.

[1] Notes to accompany a Map of the Northern Portion of the Dominion of Canada, East of the Rocky Mountains, p. 57 R., Annual Report, 1886.

[2] De Rance, in Nature, vol. xi. p. 492.

Dr. Bessels, again, remarks on the abundance of boulders on the shore of Smith's Sound in lat. 81° 30′, which are manifestly derived from known localities on the Greenland coast much further southward, and adds, "Drawing a conclusion from such observations, it becomes evident that the main line of the drift, indicating the direction of its motion, runs from south to north."[1]

It may further be mentioned that Dr. R. Bell, of the Canadian Geological Survey, has found evidence of a northward or north-eastward movement of glacier-ice in the northern part of Hudson Bay, with distinct indications of eastward glaciation in Hudson Strait.[2] For the Northern part of the Great Mackenzie Valley we are as yet without any very definite information, but Sir J. Richardson notes that Laurentian boulders are scattered westward over the nearly horizontal limestones of the district.

Taken in conjunction with the facts for the more southern portion of the Continent, already pretty well known, the observations here outlined would appear to indicate a general movement of ice outward, in all directions, from the great Laurentian axis or plateau which extends from Labrador round the southern extremity of Hudson Bay to the Arctic Sea; while a second, smaller, though still very important region of dispersion—the Cordilleran glacier-mass—occupied the Rocky Mountain region on the west, with the northern and southern limits before approximately stated.

I have refrained from entering into any detail at this time in respect to the glaciation of the northern part of the Cordillera belt, as it is probable that within the year we shall be more fully informed on the subject, as the result of observations to be expected from Mr. R. G. M'Connell of this Survey. Mr. M'Connell is now on the Mackenzie River, which, as well as the Porcupine branch of the Yukon, within the Arctic circle, it is intended that he shall examine during the summer.

IV.—Notes on the Sauropterygia of the Oxford and Kimeridge Clays, mainly based on the Collection of Mr. Leeds at Eyebury.

By R. Lydekker, B.A., F.G.S., etc.

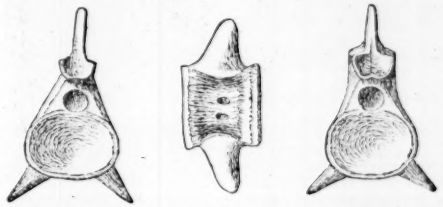
I PRESUME that most English students of Mesozoic Reptiles are acquainted, at least by report, with the magnificent collection of the remains of Sauropterygians and other Saurians from the Oxford Clay of Northamptonshire in the possession of Mr. A. N. Leeds, of Eyebury, near Peterborough. Those, however, who have not had the good fortune to see this unrivalled collection, can have no idea of its richness, or of the light it throws on the organization and affinities of the Sauropterygians of the later Jurassic seas. Till a few weeks ago I was among the number of those to whom this collection was known merely by report: but at the end of June I availed myself of Mr. Leeds' courteous invitation to see and study his

[1] Nature, vol. ix.

[2] Annual Report Geol. Surv. Canada, 1885, p. 14 D.D.; and Report of Progress, 1882-84, p. 36 D.D.

collection as fully as I might desire. On arrival, my astonishment was unfeigned to find that this collection comprised not, as I expected, only one or two imperfect skeletons of one or more species, but in some cases as many as five or six almost entire skeletons belonging to as many individuals of four well-defined species. The specimens are arranged on shelves and in trays in two rather small rooms, which they almost completely fill; and so perfect are many of them that there would be no great difficulty in mounting entire skeletons of these extinct Saurians in the same manner as those of existing Cetaceans are exhibited in our Museums. In many cases every process and spine of the vertebræ is absolutely perfect, owing to the careful and patient manner in which Mr. Leeds has personally extracted the skeletons from the soft clay in which they lay embedded. The paddles too, which have been such a stumbling-block to the palæontologist, have every bone in its natural position, so that there can no longer be any doubt as to their mode of arrangement.

Apart, however, from the intrinsic perfection of this collection, its great importance consists in the clearing up of the relations and affinities of the many so-called species of Sauropterygians which have been described upon more or less imperfect remains from the Oxford Clay. In order to avail myself of the full advantages to be gathered from a visit to this collection, I had carefully studied all the specimens previously described from this horizon; and, through the courtesy of Prof. A. H. Green, I had the further advantage of having the type vertebræ on which the late Professor Phillips founded his *Plesiosaurus Oxoniensis* and *P. plicatus* at the British Museum.



1 2 3

Fig. 1.—Posterior (1), hæmal (2), and anterior (3) aspects of a cervical vertebra of *Plesiosaurus plicatus*, from the Oxford Clay, ½. (After Phillips.)

The first skeleton to which I directed my attention was the somewhat imperfect one which Prof. H. G. Seeley described some years ago in vol. xxx. of the Geological Society's Journal, under the new generic and specific name of *Muræosaurus Leedsi*. Since that specimen was found Mr. Leeds has obtained several other much less imperfect skeletons of both immature and adult individuals, which he refers, and in my judgment quite correctly, to the same species. The immature skeletons show, however, that the cervical vertebræ are quite indistinguishable from those from the Oxford Clay near Oxford, to which Prof. Phillips applied the name *P. plicatus* (Fig. 1); and the specific name *Leedsi* must, therefore, yield place to this earlier one. The most important point, however, on which these new skeletons throw

light is the structure of the pectoral girdle. It will be remembered that the genus *Murænosaurus* was founded upon a supposed peculiarity of this part of the skeleton—to wit, that the preaxial border of the coracoids was not connected by a median bony bar with the precoracoids (using the terms employed by Mr. J. W. Hulke). Now the new specimens show that this restoration of the pectoral girdle is solely due to the imperfection of the type specimen; and, as Mr. Leeds at once pointed out to me, the portion of the scapulo-precoracoid regarded as the precoracoid in the figure given in the Q.J.G.S. vol. xxx. p. 448, and made to meet its fellow in the middle line, is really the dorsal part of the scapula. The pectoral girdle is in fact of the same general structure as that figured by Prof. Seeley on p. 447 of the same volume as the type of the so-called *Colymbosaurus*; and there appears to be no distinction, so far as regards the pectoral girdle (on which the two were founded), of both *Murænosaurus* and *Colymbosaurus* from the earlier *Elasmosaurus* of Prof. Cope. If, however, we follow Mr. Hulke in retaining the Jurassic and Cretaceous Sauropterygians exhibiting this modification of the pectoral girdle in the original genus *Plesiosaurus*, of which they form a well-marked group, then we may continue to use the name *Plesiosaurus plicatus* for this species. An allied, and apparently unnamed species, represented in Mr. Leeds' collection, and distinguished by its shorter cervical vertebræ, which are also fewer in number, is also known to me by a considerable portion of a skeleton obtained from the Oxford Clay of Weymouth. This form I shall describe, and if necessary name on a future occasion; Mr. Leeds having kindly lent me one of the cervicals of his mature example.

The next species I have to mention is *P. Oxoniensis*, represented by several nearly entire skeletons in the Eyebury Collection. Of the specific identity of these examples I have satisfied myself by a comparison with the type cervical and dorsal vertebræ in the Oxford Museum. This species was referred by Prof. Seeley to a subgenus of *Murænosaurus*—I presume on the evidence of a pectoral girdle figured in Phillips's "Geology of Oxford" (p. 310), which is turned the wrong way upward and described as the pelvis. The coracoids (pubes) in that example are, however, I believe, referable to the so-called *Plesiosaurus philarchus*; and the Eyebury specimens show that the pectoral girdle was of the type of the so-called *Colymbosaurus*. These specimens show, moreover, that the remarkable pectoral limb from the Oxford Clay of Bedford, figured by Phillips on p. 315 as a pelvic limb, and made the type of *P. eurymerus*, is really referable to *P. Oxoniensis*; the limb figured on p. 312 of the "Geology of Oxford" under the latter name apparently belonging to *P. plicatus*.

A fourth species represented in Mr. Leeds' collection is the so-called *Plesiosaurus philarchus* of Prof. Seeley, characterized by its long mandibular symphysis. The examples of this species show that in the young there were two distinct costal facets in the cervical vertebræ; while the teeth, and pectoral and pelvic girdles, present a great resemblance to those of *Pliosaurus*. This species seems to

be closely allied to *Thaumatosaurus oolithicus*, of the Lower Jurassic of Würtemberg, in which the teeth have the same structure and the cervical vertebræ are likewise furnished with two costal facets. The latter species, again, appears to come so close to the Upper Liassic *Plesiosaurus Cramptoni*—the type of Prof. Seeley's genus *Rhomaleosaurus*—that with our present material not even specific characters can be recognized. On these grounds I am inclined to include all these three species, together with the Lower Liassic *P. megacephalus*, in a single genus, for which the name *Thaumatosaurus* should be adopted. This reference I shall again have occasion to mention in an addendum to a paper on the Oxfordian species in the "Geological Society's Journal"; the knowledge I have gained since that paper was read having induced me to remove that species from the genus *Plesiosaurus*. Mr. Leeds' examples show that a small omosternum was present.

Of the genus *Pliosaurus* Mr. Leeds possesses only a number of detached teeth, which differ from those of the Kimeridgian forms in the imperfect development of the "carinæ," and the absence of the distinct smooth and flat intercarinal space. These teeth appear indistinguishable from the one from the Oxfordian of Boulogne described and figured by M. Sauvage under the name of *Liopleurodon ferox*. I can see, however, no reason why this species should be separated from the Owenian genus, and it may accordingly be known as *Pliosaurus ferox*. The cervical vertebræ from the Oxford Clay in the Cambridge Museum to which Prof. Seeley has applied the name *P. pachydirus*, without, however, giving any specific diagnosis, are probably referable to the same species.

Leaving now the Eyebury Collection with the expression of my thanks to its owner for his courtesy in placing it thus freely before me, our attention may be directed in the remaining part of this paper to certain large Plesiosaurian remains from the Kimeridge Clay, which are allied to *P. Oxoniensis*. In the first place I may mention that after leaving Peterborough I availed myself of the permission of Mr. Marshall Fisher, of Ely, to visit his collection, which contains the pectoral girdle figured by Prof. Seeley on p. 447 of the thirtieth volume of the "Geological Society's Journal," under the name of *Colymbosaurus*, and thence proceeded to the Woodwardian Museum at Cambridge to have one more look at the vertebral column to which the same authority has given the name of *Plesiosaurus megadirus*; both specimens being from the Kimeridge Clay of the Cambridgeshire district.

Before going further it is, however, necessary to recapitulate briefly the history of these large Kimeridgian Plesiosaurs. In the "British Association Report" for 1839, Sir R. Owen described a propodial bone (humerus or femur) of a large Plesiosaur from the Kimeridge Clay of Shotover in the collection of the late Lord Enniskillen, under the name of *Plesiosaurus trochanterius*; this specimen being now in the British Museum. Its structure is shown in the accompanying woodcut of another example. In the year 1841 this species, together with *P. grandis*, was referred to the genus *Pliosaurus*; of which the

type is *P. brachydirus*, described in the previous year in the same writer's "Odontography." In 1869 Prof. Seeley, in his "Index to the Woodwardian Museum," applied the name *Plesiosaurus megadirus* to the above-mentioned vertebral column in the Cambridge Museum; merely, however, mentioning its large size and the number of the cervical vertebræ, and the description being therefore insufficient to authenticate the name. A second imperfect skeleton, in the same collection (presented by Mr. Stead Jones), was referred to the same species; that specimen having a propodial of the peculiar type of *P. trochanterius*. In the following year Mr. Hulke described in the Q.J.G.S. vol. xxvi. the vertebral column, the pectoral and pelvic propodials, and the imperfect coracoids of a large Plesiosaur from the Kimeridge Clay of Dorsetshire under the name of *P. Manseli*; and also certain dorsal vertebræ remarkable for their very short centra, to which the name *P. brachistospondylus* was accordingly applied. In the course of the description of the former species the resemblance of the propodials to the type of *P. trochanterius* was pointed out, and no very good reasons were given why the specimen should not have been referred to that species, which was thus proved to be Plesiosaurian.

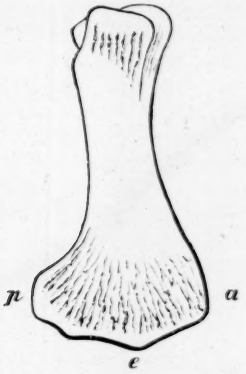


FIG. 2.—Dorsal aspect of the right humerus of *Plesiosaurus trochanterius*; from the Kimeridge Clay, $\frac{1}{10}$. *a*, preaxial, *p*, postaxial border; *e*, division between radial and ulnar facets. (After Phillips.)

Reference was also made to *P. megadirus*, which was considered to be closely allied, although it was stated that in the opinion of Mr. W. Davies it was not identical. It should be added that Mr. Hulke's types are preserved in the British Museum. The year 1871 saw the publication of Phillips's "Geology of Oxford," in which work vertebræ of large Plesiosaurs from the Kimeridgian of Oxfordshire were described under the names of *P. brachyspondylus* and *P. validus*; the former being wrongly identified with *P. brachyspondylus* of Owen, which is really a Pliosaur, and the latter being regarded as new. No reference (perhaps owing to the close sequence of the two works) was, however, made to Mr. Hulke's *P. Manseli*; and detached

propodials were described under the name of *P. trochanterius*. *P. brachyspondylus* was regarded as the Kimeridgian analogue of *P. Oxoniensis*; the vertebræ having the same short and distinctly cupped centra, which characterize both that species and *P. Manseli*. It should also be observed that Phillips described another large Kimeridgian Plesiosaur, which had flattened terminal faces to the centra, and is closely allied to *P. plicatus*, which belongs to a totally different subgroup. Thus matters stood till 1874, when in vol. xxx. of the Q.J.G.S., Professor Seeley figured on p. 447 the above-mentioned pectoral girdle from Ely, under the new generic title of *Colymbosaurus*; stating on p. 445 that the type species was to be *P. megadirus*, which, as already stated, had never been sufficiently described. It was also mentioned on p. 448 that *Plesiosaurus Manseli* was to be referred to a subgenus of *Murænosaurus*.

With these facts we may proceed to criticism. In the first place I cannot find any characters by which *P. Manseli* can be distinguished from *P. trochanterius*, and since the description of the latter is sufficient, I consider that we should adopt the earlier name. *P. brachistospondylus* appears, moreover, to be founded upon dorsal vertebræ of the same species which have been subjected to a strong crush in the axial direction. I have compared the vertebræ figured by Phillips under the name of *P. brachyspondylus*, and also the types of his *P. validus*, with the corresponding vertebræ of the column described by Mr. Hulke, and find an absolute identity between the two; the difference on which Phillips separated *P. validus* from *P. brachyspondylus* being merely due to the different serial position of the vertebræ, and to an erroneous restoration of the neural arch. With regard to the type skeleton of *P. megadirus*, Prof. Hughes has been good enough to send some of the cervical vertebræ to London, and from comparing these, and from a personal examination of the rest of the skeleton two days after having carefully examined that of the so-called *P. Manseli*, I am fully and absolutely convinced of the specific identity of the two. This is also borne out by all the detached vertebræ of this type from the Cambridgeshire district in the British Museum, which cannot be distinguished from those of the latter. Further evidence is afforded by the above-mentioned paddle in the Cambridge Museum, and by another in the collection of Mr. Fisher, in both of which the propodial is of the *P. trochanterius* type.

Now comes the question of the pectoral girdle on which *Colymbosaurus* was founded. As this was referred definitely by its describer to the so-called *P. megadirus*, I had imagined that it was associated with vertebræ of the same type as those of the latter; but my astonishment on arriving at Ely was considerable on hearing from Mr. Fisher that it was an entirely isolated specimen. Although I think it most probable that this specimen is referable to the present form—that is, *P. trochanterius*—yet Prof. Seeley, on the supposition that these two forms were distinct, had no more grounds for referring it to *P. megadirus* rather than to *P. Manseli*, unless he assumed that all the Cambridgeshire specimens belonged to the former and all the Dorsetshire to the latter. Even then, however, there was also the

possibility of this specimen belonging to the large form allied to *P. plicatus* (for which I propose to adopt Owen's name *P. truncatus*), of which there are vertebræ from Ely in the British Museum.

So far, therefore, as I can see, the forms described under the names of *P. trochanterius*, *P. megadirus*, *P. brachistospondylus*, *P. Manseli*, *P. brachyspondylus* (Phillips), and *P. validus*, belong to one and the same species. On the evidence of a detached pectoral girdle Prof. Seeley has, however, made *P. megadirus* the type of the genus *Colymbosaurus*, while *P. Manseli* is referred to a second genus, *Muræosaurus*, apparently on the evidence of the broken coracoids of the type specimen. I think it very probable, as already said, that the pectoral girdle in question does belong to the present species; and I believe, moreover, that the pectoral girdle of the type specimen of *P. Manseli* when complete was (as Mr. Hulke states on p. 59 of the "Proc. Geol. Soc." for 1883) of precisely the same general form; this form having apparently obtained in all the Upper and Middle Jurassic Plesiosaurs.

As a climax to the treatment to which Plesiosaurs have been subjected we may notice Prof. Cope's restoration of the so-called *Elasmosaurus platyurus*, given in the "Trans. Amer. Phil. Soc." vol. xiv. pt. i. pl. ii. In this instance the head has been placed at the extremity of the tail; and the Professor is consequently led to remark in his description that in the vertebræ the prezygapophyses present the unheard-of peculiarity of looking downwards instead of upwards, while the so-called cervicals are indistinguishable from the caudals of other forms.

Finally, after long consideration I have come to the conclusion that it will be convenient to separate from *Plesiosaurus* all those supra-Liassic species having single costal facets and a pectoral girdle without omosternum and the coracoids united by a median bar with the precoracoids. For these forms I propose to adopt the name *Cimoliosaurus*. Leidy, as being the earliest of the numerous terms which have been applied to this group. The typical forms have flattened terminal faces to the vertebræ; but I do not propose to generically separate these forms like *Plesiosaurus trochanterius* and *P. Oxoniensis* in which these faces are cupped; although if such separation should be found advisable, I believe the term *Polycotylus* of Cope is the one which should be adopted. I shall show on another occasion that *Elasmosaurus* of Cope is not separable from *Cimoliosaurus*.

V.—Outcrops.

By W. W. Watts, M.A., F.G.S.,

Fellow of Sidney College, Cambridge, and sometime Deputy-Professor of Geology at Oxford.

NOW that mapping constitutes such an essential part of field-work, it may be of use to some of your readers to connect together a few rules which have occurred to me on this subject.

Valley-Outcrops.—Professor Green has devised an admirably common sense method by which the outcrop of a flat rock-bed can be

traced by means of contour lines. The main results gained from this method may be thus summed up:—

1. A bed of rock parallel with the waterway of a valley crops out in two parallel lines. If the plane be turned through 180°, the lines begin to meet (*a*) *down* the valley where the inclination is in the same direction as, and greater than, that of the waterway; in every other case (*b*), they meet *up* the valley.

2. Where the strike crosses the waterway obliquely, the sharpest change in the outcrop line will be on that side of the valley where the acute angle made by the strike with the contour lines is *smallest* in case (*a*), and greatest in case (*b*).

Fig. 1. Fig. 2.

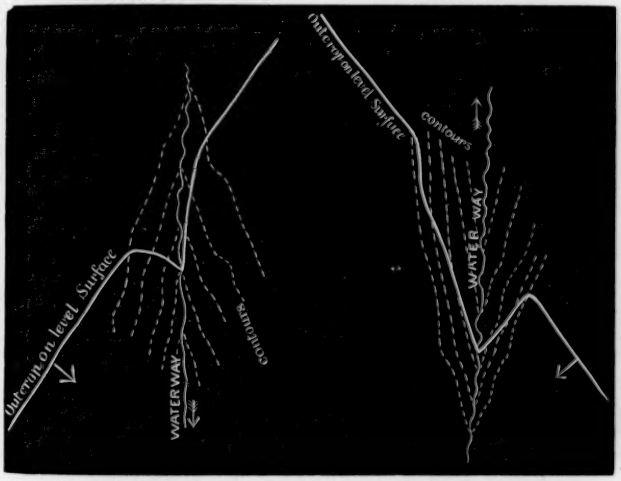


Fig. 1. Outcrop in valley; strike oblique; dip with waterway.
Fig. 2. Ditto ,, ,, ; dip against waterway.

Strike-faults.—Sometimes one is apt to think that the whole nomenclature of faults is unsatisfactory, and some of the terms used, *hade* particularly, misleading. But a little careful consideration will convince us that it is quite right to refer the inclination of hade to a vertical plane and not to one at right angles to the strata: for the two forces responsible for the results of faults are gravitation and crust-crushing, and these two forces together determine the direction of movement. After drawing all the possible cases of strike faulting it is clear that all normal faults, as ordinarily defined, are due to movement under the influence of gravitation where rocks have been *stretched* and cracked, and have moved so as to *gain* space. Reversed faults, on the other hand, are those in which *compression* has occurred and space has been *saved*.

The result is that all normal faults, with one exceptional type, tend to *repeat* the outcrop of beds, while reversed faults, with a parallel exception, have a tendency to *conceal* beds. As the exceptions belong to types of frequent occurrence, Figs. 3 and 4 illus-

trate them, and it will be observed that in both cases the hade of the fault is in the *same* direction as the dip, but at a *greater* angle than it. To contrast with these figures I have chosen two other faults for Figs. 5 and 6, each belonging to one of the other two types.

Fig. 3. Fig. 4.

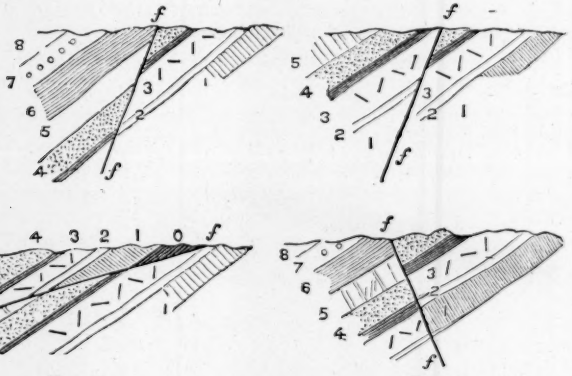


Fig. 5. Fig. 6.

Fig. 3.—Normal fault, concealing bed 5.
Fig. 4.—Reversed fault repeating beds 3—4.
Fig. 5.—Normal fault repeating beds 0—1.
Fig. 6.—Reversed fault, concealing bed 5.

Additional complexities will of course be introduced if faults have a hade lower than the angle of ground slope; but I prefer to leave each such case to be dealt with on its own merits.

Dip-faults.—The result of a number of drawings of faults shows that the following law exists. The outcrop on the upthrow side is pushed *forward* in the direction of *dip*, unless the angle of the latter is less than that of the ground slope, when the reverse occurs. Good figures will be found in the manuals by Professors Green and J. Geikie.

Connecting together the exceptions in all these cases, we find they occur—when the strata dip at (1) a *less* angle than (*a*) the *ground* in a *dip* fault, (*b*) the *hade* in a *strike* fault, and (2) at a *greater* angle than the ground in the *valley* outcrop.

VI.—On a Portion of the Osborne Beds of the Isle of Wight, and on some Remarkable Organic Remains recently discovered therein.

By G. W. Colenutt, Esq.

At several places along the north-eastern coast of the Isle of Wight the Osborne Beds crop out on the shore to some extent and admit of examination. From the great difficulty which is usually experienced by geologists in getting at any workable section or outcrop of these beds but little, one might say almost nothing, is known about them. There are few divisions of the Tertiary strata of the Island which present so many variations both of composition

and of fossil contents as do the Osborne Beds at their various outcrops; and at the three places where they are most usually examined —at Whitecliff Bay, at St. Helen's, and at Alum Bay—they yield few fossils, and there is nothing extraordinary about the composition of the clayey strata. On the contrary, at several places between St. Helen's and Osborne these beds crop out from underneath the overlying Bembridge Limestone at places which might easily be overlooked, and present very remarkable features both as to their composition and as to the fossils which they contain. Some description of these strata, and of the organic remains contained in them, may be of interest, as so little is known of them; and the more so as it has been my good fortune to discover in some of the clays organic remains which there is reason to believe are quite new, if not to science, at least to our English strata.

The Osborne Beds in the East Medina may be examined on the shore at several places, more especially below Chapelcorner Copse, between King's Quay and Wootton Creek: just to the west of the boathouse on the shore below Binstead House: on the shore below Ryde House: and immediately to the south-east of Sea View Pier. At all these places the most interesting clays are exposed not in the cliff, but on the beach itself; consequently the strata are not very often seen, being usually covered up and hidden by the shingle and sand of the beach, and more especially so at the last three of the above-named places. At Chapelcorner Copse, on the contrary, the section is generally fairly well exposed, as there is comparatively but little shingle and sand to the west of Wootton Creek; and, as they are practically identical, it will be well to take the strata here as representative of those at the other localities.

It is very difficult to get exact measurements on account of the cliff for some distance inland being covered by a sliding talus of grey and yellow clays thickly covered with underwood. The Bembridge Limestone will, however, be observed in the top part of the cliff and under this we find the following approximate section:—

	Ft.
(In the cliff.)	
1. Marls and yellow-grey and dark red and mottled clays	about 40
(On the beach.)	
2. Grey clay with scattered fish bones, scales, etc.	,, 4
3. Hard blue and grey shaly clay with small perfect fossil fish	,, 2
4. Hard grey clay with matted masses of leaves and lenticular masses of cement-stone	,, 3
5. Blue clay with many seams of crushed *Paludina lenta* and *Melanopsis carinata*	,, 6
6. Unfossiliferous soft green clays extending to low-water mark.	

The clays numbered 2, 3, 4, and 5 in the above section are the most important, and afford valuable information as to the flora and fauna which flourished when they were deposited.

In number 2 thin lenticular masses of crushed fish bones occur, with many ganoid scales and fish vertebræ (*Lepidosteus*): teeth, bones, and dermal plates of *Alligator Hantoniensis* (?): bones and plates of *Emys*, *Trionyx*, and *Chelone*: incisor and molar teeth and

bones of a small rodent (*Theridomys*) [rare] : a small snake vertebra was found among the crushed bones and also a jaw of *Lepidosteus* (?).

In number 3 the most remarkable fossils are found in a hard, dark grey laminated clay, and consist of small exquisitely perfect teleostean fish, varying in length from three-quarters of an inch to three inches: also bones, scales, and vertebræ of larger fish : crustaceans apparently allied to the shrimp or prawn and measuring from half an inch to two and a half inches in length [rare] : *Cyprides* : occasional masses of crushed *Paludina lenta* and *Melanopsis carinata* : a few scattered ganoid scales : and spines and bones of larger fish.

In number 4 seams of compressed vegetable remains occur: a few leaflets of ferns [rare] : small carbonized seed vessels, with longitudinal striations (not yet identified) : a few small twigs of a Conifer: occasional masses of lignite : and detached fragments of turtle plates.

In number 5 *Paludina lenta* and *Melanopsis carinata* occur abundantly in thin seams, but they are mostly in a crushed state. No other species of Mollusca have been observed. Vertebræ of large fish occur, especially in a thin seam of finely comminuted shells at the base of this division : teeth apparently of *Alligator Hantoniensis* are found in this division, but they are rare here ; a few detached turtle plates are found, but they are not so often met with here as in the clay a little higher up.

In number 6 and in number 1 I have not been able to discover the existence of any organic remains at all.

The strata have a very slight dip of about 5° or 6° to the south; but this dip, close to the base of the cliff, is much increased—caused no doubt by the weight of the talus, which in wet weather is in a very soft and oozy state, and is always on the move down towards the shore.

The beds above described occupy about the middle of the Osborne series, but the dark clay in which the small perfect fish occur is no doubt a local deposit, although it occurs at Binstead House, Ryde House, and at Sea View, as well as at Chapelcorner Copse. The distance is about $5\frac{1}{4}$ miles, as the crow flies, between the furthest outcrop of the fish clay to the west (at Chapelcorner Copse), and the furthest outcrop to the east (on the shore in the angle formed by the sea-wall immediately to the south-east of Sea View pier). Thus it will be seen that the deposit is of considerable extent, although it is no doubt correctly considered as local.

Although I have at every opportunity made a most careful search, I have never been able to discover the presence of this clay at any of the other places in the island where the Osborne Beds are exposed. At Whitecliff Bay, where the Osborne Series is visible in its entirety, I have been unable to find any trace of the fish clay; neither have I at Gurnard Bay, nor at any of the other sections in the West Medina. The shore sections between Ryde and Sea View are much obscured by the sea-wall which runs the entire distance, thus preventing any examination of the clays which would crop out along the beach and low cliffs.

The small fossil fish from division 3 are most beautifully pre-

served—even the minute rays of the fins and tails being most clearly defined. From the fact that the fish are largely impregnated with iron pyrites, they present a beautiful golden appearance, especially when first exhumed from the clay. The head is not, as a rule, so well defined as the other portions of the body, yet it is very often possible to see the eye preserved as a black spot, and the discolouration of the intestines is sometimes seen in the specimens. It is not usual to meet with one fish alone, but they generally occur in small shoals—the remains of no less than *nine* separate and distinct fish being imbedded in a small slab of clay measuring two and a quarter inches square, which I have in my cabinet. This, however, is an exceptionally good shoal. A good deal of iron pyrites occurs in the clay in small soft, gritty, dark-grey masses, and some of the larger specimens of the fish are much disfigured and spoilt by the iron pyrites with which they are encrusted, and into which they are transformed. In several other divisions of the clay we find iron pyrites matting the shells together into thin slabs, and occurring as irregular brown masses in the clays.

It is always very interesting to endeavour to ascertain from the evidences presented, the origin and mode of formation of a local or accidental deposit like the fish clay, and to arrive approximately at some idea of the state of things both before and after the occurrence happened which gave rise to the deposit.

In the clays underneath the fish clay we find evidences of the existence of a comparatively tranquil lake or river inhabited by *Paludina, Melanopsis, Cypris, Trionyx*, and other similar forms. The flora is represented by crushed masses of vegetable remains and by plants of which we find the seeds (not yet identified). A few ferns existed on the land, but the remains of these are very rare, as also are the few remains of conifers. That the area of deposit was but little disturbed is evident from the perfect condition in which the vegetable remains are preserved, for they show no signs at all of having been subjected to attrition. But a change took place in the form of a sudden influx of mud and foreign matter. It remains to be seen from careful and expert examination whether the fish which we find in this clay may be assigned to any genus of fish inhabiting the sea, or whether they are clearly of freshwater origin; and very considerable interest attaches to the solution of this question. That the fish were smothered by the mud is perfectly clear, for the result even of a day's decay would be to damage and spoil the delicate bones of the fins and tails. Then again, these fish are found entombed in a perfect state in small shoals, which would not be the case had they died a natural death and been drifted together—they would be more or less damaged by the drifting process. And I have never found vegetable or any other remains mixed up with the fish—which one would expect to do in the case of drifted exuviæ. In several cases the fish have been compressed flat without being laid on their sides, and in these cases we see the fish from above and do not see the dorsal fin at all, but both eyes are visible in the form of two black spots, one on either side of the head. Masses of commi-

nuted bones of larger fish do occur, but not on the exact horizon occupied by the small perfect fish—they are either just above or just below. The shrimps or prawns, which are found on precisely the same horizon as the perfect fish, are too in a very perfect state, and this is another fact in support of death by smothering. It seems doubtful whether such crustaceans as these—the largest I have measures about two and a half inches in length—were inhabitants of freshwater, but rather were drifted into the river or lake from the sea with the mud (and possibly with the small fish) and there entombed alive. Again, the texture of this fish clay is quite different from anything above or below it—indeed it is quite different from any of the Tertiary clay of the Island—being shaly and readily splitting into layers. It has also a well-defined transverse jointing, and this property is the cause of its easily dividing into irregular masses, in which state it is often rolled about by the waves and water-worn into rounded nodules. There is one very thin seam of *Paludina* and *Melanopsis* forming the top layer of the fish clay, as though after the fish clay had been deposited, the freshwater inhabitants had all been killed also by the influx of salt water or other agency; in the clay above no remains of mollusca are found at all. The whole scheme of life seems to have changed and the only organic remains are those of large fish and reptiles with the bones of a few small mammals. Above the horizon of these seams of fish bones we find nothing but grey and yellowish and red mottled unfossiliferous clays of varying hardness, which seem to point to water—probably of a brackish nature—but with an almost total absence of the usual freshwater life.

Above these beds of clay comes the Bembridge Limestone showing the reverting to purely freshwater conditions, and the consequent recurrence of a freshwater fauna.

The small fish and the shrimps were first discovered in the year 1876, at Ryde House, and since that time I have, from the several localities, obtained about one hundred and fifty specimens of the former and about twelve specimens of the latter.

[N.B.—Mr. E. T. Newton, F.G.S., of the Museum of Geology, Jermyn Street, is examining and naming the fish and Crustaceans mentioned in this paper, and his description of them will appear in due course.]

VII.—On *Hindeastræa*, a New Generic Form of Cretaceous Astræidæ.

By Dr. Charles A. White.
Palæontologist, U.S. Geological Survey.

THE little Coral here described was discovered in Kaufman County, Texas, in strata of the Ripley Group, by Dr. R. H. Loughridge, and presented by him to me, together with a few characteristic molluscan species of that group which he found associated with it. The Ripley Group is the uppermost division of the Cretaceous series in the States which border upon the Gulf of

Mexico; and probably represents approximately the Upper Chalk of England. Regarding it as a new generic form I herewith give a diagnosis and figures of it; and being the only species known to me, the diagnosis is necessarily based upon this alone.

HINDEASTRÆA, gen. nov.

Corallum depressed or discoid, simple in the earlier stages of growth, but afterward becoming compound by gemmation; basal epitheca marked by both radiating striæ and concentric rugæ: corallites few, without true columella, their outer walls fused together when in contact, and moderately strong; radiating septa bilaminate, subequal in thickness at their peripheral ends, consisting of three or four cycles as regards their length, subspinulose, tuberculose, or rugose upon their sides and upon their free upper edges; dissepiments few or absent.

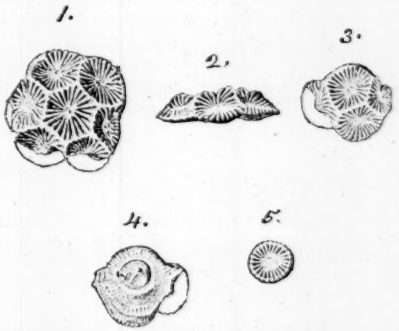


Fig. 1. Calicular view of the largest example discovered.
Fig. 2. Lateral view of the same.
Fig. 3. Calicular view of a medium sized example.
Fig. 4. Under view of the same, showing the basal epitheca.
Fig. 5. Calicular view of a corallite upon which no gemmation has occurred. All the figures are of natural size.

This genus is related to *Isastræa*, E. and H., but it differs from the latter in its mode of growth, *Isastræa* being massive, and the dissepiments of its corallites being usually numerous and well developed. The extreme shortness of the axis of the corallites of *Hindeastræa* gives little or no space for the development of dissepiments. The walls of the corallites also form more distinct boundaries between the calices than is usual in *Isastræa*.

The generic name is given in honour of Dr. G. Jennings Hinde.

HINDEASTRÆA DISCOIDEA, sp. nov.

Corallum irregularly discoid or much depressed, attached by the apex of the original corallite, or free; corallites few, very short but moderately broad; the walls of the adjacent corallites usually in contact and fused together, when the border is polygonal; but they sometimes have a tendency to separate, when the border is subcircular; calices slightly concave or nearly flat; their borders more or less prominent and clearly defined; radiating septa prominent,

22 to 26, usually 24, in number; those of the first cycle four to six in number, reaching nearly or quite to the centre of the corallite, where they are more or less contorted. Those of the second cycle do not usually terminate interiorly by free ends, but are there joined to one another or to those of the first cycle. Those of the third cycle usually terminate like those of the second, but are sometimes free at the inner end; the sides and free edges of the septa subspinulose or tuberculose. The number of corallites in a corallum varies from one to seven or eight, their gemmation taking place at the margin of the calice, and usually after the original corallite had attained considerable size.

Diameter of the largest calice observed, 8 millimeters.

The type specimens[1] are preserved in the U. S. National Museum, at Washington.

WASHINGTON, *June 12th*, 1888.

NOTICES OF MEMOIRS.

I.—"SUR LES TÉLÉOSTÉENS DU RUPÉLIEN." By L. DOLLO and R. STORMS. (Zool. Anzeiger, No. 279, 1888.)

MESSRS. DOLLO and STORMS have undertaken the investigation of the Fossil Fishes of the Mesozoic and Tertiary deposits of Belgium, and we are glad to welcome the first brief instalment of the results of their joint researches. The present note deals with the systematic position and nomenclature of the genera *Sphyranodus*, Agassiz, and *Scomberodon*, P. J. van Beneden. *Dictyodus*, Owen, is adopted as the correct name for the so-called *Sphyrænodus*, and the fish is referred to the Scombridæ, on account of the characters of its dentition, premaxilla, palatine, mandible, and the caudal region of the vertebral column. It is respectively separated from *Cybium* and *Pelamys*, its nearest allies, by its single series of large conical palatine teeth, and by the greater strength of its dentition and premaxilla. *Scomberodon* is considered to be identical with *Cybium*, and the type must henceforth be known as *Cybium Dumonti*.

A. S. W.

II.—PROF. DR. W. DAMES ON *GIGANTICHTHYS PHARAO*. (Sitzungsb. Ges. naturf. Freunde Berlin, 1887, p. 137.)

THE generic name *Titanichthys* being preoccupied, Prof. Dames suggests that of *Gigantichthys* for the large Cretaceous fish-teeth from Egypt, already described under the name of *Titanichthys pharao* (see GEOL. MAG. for April, 1888, p. 157).

[1] Specimens of this Coral have been presented to the British Natural History Museum through Dr. G. J. Hinde.

REVIEWS.

I.—British Petrography, with Special Reference to the Igneous Rocks. By J. J. Harris Teall, M.A., F.G.S. (London, Dulau & Co., 1888.) Royal octavo, pp. 470, with 47 Chromo-lithographic Plates.

FOR some years students have been longing for a well-illustrated and comprehensive work on the mineral structure of rocks. Memoirs on certain parts of the subject, such as Wadsworth's Lithological Studies, or Zirkel's Microscopical Petrography, were accessible without much difficulty; there was the Minéralogie Micrographique of MM. Fouqué and Lévy, with its splendid illustrations, but this is written too much from the mineralogical point of view for the ordinary student, and Professor Rosenbusch's "Mikroscopische Physiographie der massigen Gesteine," though a treasure house of erudition, is vitiated by a faulty principle of classification, and is almost without illustrations. Moreover, it is not every student who can read French or German with as much facility as English. We have now a book in our own language which is comparable in its illustrations with that of Fouqué and Lévy, and in its erudition with the treatise of Rosenbusch. True, it deals only with British rocks, but these are so comprehensive, that there is comparatively little wanting to make it a complete work of reference so far as those of igneous origin are concerned.

The work is illustrated by several woodcuts interspersed in the text and by 47 coloured plates—the former occasionally leave something to be desired in clearness, but the latter as a rule are excellent, and are accompanied by outline key-plates. The examples on the whole appear to be very judiciously selected. The task before Mr. Teall was not quite so difficult as the proverbial decanting the Ocean into a pint pot; but still the plethora of wealth must have caused him no little embarrassment. If we were disposed to take exceptions, we should say that a little too much favour had been shown to the more basic rocks, though in these we still desiderate a tachylite, and to the pyroxenic group of minerals, and that the selection of the non-igneous rocks, necessarily a very restricted one, was not in every case the best possible. Of the 47 plates, rather more than eight are devoted to the peridotites, picrites, and serpentines, and it takes full thirty plates to get clear of the more basic half of the igneous rocks. Thus, the more acid group—granites, quartziferous felstones, pitchstones, and kindred rocks—seem to us rather inadequately represented. It is, no doubt, difficult among so many excellent figures to suggest excision, but we doubt whether two are needed in the case of quartzite, and whether the student will learn much from that of a crushed quartzite. Indeed, either the figure is not very successful, or the rock prior to its deformation was not very like the normal quartzite represented in the upper part of the plate, but must have been a much "dirtier" example. Again, the deformed volcanic breccia in plate xlv. should have been placed side by side with a normal specimen. Indeed, throughout the book

we think the author leans a little too much upon dynamic metamorphism, real or supposed. Thus, there is only one figure illustrating contact metamorphism in a sedimentary rock, and that is the somewhat abnormal case of the chiastolite slate of Skiddaw. We should have gladly seen with it an example of the mica-andalusite rock which occurs in the same region nearer to the intrusive granite. But when one remembers the exceptional difficulties under which Mr. Teall has accomplished his task—for the failure of the first publisher threatened to shipwreck the book, at a comparatively early stage of its issue, and the author has completed it, at his own risk, without any hope of profit, and with more than a possibility of loss—it seems ungenerous to cavil at minor blemishes, for the book now comes almost as "a gift-horse."

So we will allow ourselves but one other criticism. The title of the work does the author an injustice—it is not a *Petrography*, but a *Petrology*. No doubt, as he says, the work is to a large extent devoted to a description of the rocks so far as this is dependent on the examination of hand specimens; but the significance of the structures and of the relations of the minerals are again and again discussed; indeed, the chapters on the characters and classification of igneous rocks, on their origin, metamorphosis, and destruction, are of the highest value. We lay some stress on this verbal question, because the confusion between the two terms Petrography and Petrology is so common, especially among continental writers. Perhaps the author would thus defend his selection of a title; but we have yet to learn that "following the multitude to do evil" is a valid excuse in science any more than in ethics. The distinction between a "graphy" and a "logy" is indisputable, for it rests on the inherent significance of words—and no concurrence of authors, however eminent in science, can alter this. The "petrographer" must be content to walk with the geographer and shake hands with the photographer; to receive only a bow of condecension from the mineralogist and the geologist.

The dominant principle of Mr. Teall's work we believe to be a thoroughly sound one. It is, that to give an accurate description of a rock is a vastly more important matter than to give it a name. A rock type is to be regarded as the 'locus' in which a group of characteristics meets, as a convenient expression of a complex idea, rather than as a distinct entity. Hence, though we are obliged to name, and are bound to define with some precision, our ideal types, though it is unpardonable to misapply their names—as, for instance, to call a rock a serpentine when it contains much silicate of alumina and comparatively little silicate of magnesia—still our species, as we may call them, should be made as inclusive as possible, and precision should be obtained rather by addition of epithets than by novelty in nomenclature.

The first chapter of the book gives an admirably clear sketch of the constituents of igneous rocks, describing their various forms, microlithic and otherwise, together with an outline of the work which has been done in the study of inclusions in minerals and the

significance attached to them by various workers. Succeeding chapters summarize the chemical and physical characters of igneous rocks, giving a brief notice of the uses made of certain chemical solutions in separating rock constituents, and determining their specific gravity. Indeed, we may say that in every part Mr. Teall appears to have brought up his information to the latest date, though he wisely abstains from burdening his book with long descriptions of methods of investigation, chemical or physical. Next comes the classification of igneous rocks, where the principle already noticed is enunciated. The author also discusses the vexed question of geological age as a primary factor in classification of igneous rocks. Here British petrologists have for some years been at issue with most of their fellow-workers on the Continent. Of the ultimate result of the contest there can now be little doubt. Mr. Teall takes this position, "While declining to accept geological age as a primary factor in classification, . . . the present writer is strongly of opinion that, if possible, it should receive indirect expression. . . . So when any peculiarity of texture or composition can be shown to characterize rocks of a particular period, that peculiarity should be utilized for purposes of classification." To this concession no reasonable objection can, in our opinion, be made: probably, however, it will be rarely of avail in practice. The succeeding chapters describe the more important varieties of igneous rocks. This portion of the book will be found by the student a perfect mine of valuable information very lucidly arranged. Mr. Teall has mastered the voluminous literature of the subject, and gives an admirable summary of the result of his studies. His unwearied patience and assiduity will cause future workers to invoke blessings on his name, and to save them from being crushed, to use Professor Huxley's metaphor, beneath the gifts which have been heaped upon them; gifts, among which, as in the case of Tarpeia, there is much metal of greater weight than worth, as well as the gold. This sketch is to a certain extent critical as well as historical, as it should be, but it is executed, as a rule, in a thoroughly judicial spirit. If the author shows any bias, it is in an occasional disposition to regard dynamic metamorphism too much as an established theory rather than a probable hypothesis. Perhaps also it would have been well to have mentioned that in some cases where foliation is claimed as the result of regional or dynamic metamorphism, difficulties have been indicated and other hypotheses suggested. Still, this potent factor of change has been so overlooked of late years, that we are glad to see the student's attention called to it. It must hold a prominent place in future among the agencies of metamorphism, though we doubt whether *Ecpiesis* will ultimately enjoy a supremacy quite as universal as seems at present to be claimed by some of her newly-converted devotees!

Under each principal group the author describes the different examples and varieties of igneous rocks, according to their geographical distribution, thus adding to the utility of his book as a work of reference. There is a particularly valuable sketch of the

'Mica Traps.' The nepheline rocks of course can only be illustrated by the well-known example from the Wolf Rock, and for a leucite rock the author has had to go beyond the limits of the British Isles. Here we think a better example might have been found for figuring than that which he has selected. The principal types, however, are all briefly described in the text. There is an excellent chapter on Contact Metamorphism, and that which follows, on the origin of Igneous rocks, is one of the most valuable in the book; for it contains a discussion of the experiments by the late lamented Prof. Guthrie, on eutectic solutions, and of the no less important researches of Lagorio on the crystallization of minerals out of igneous magmas. The work concludes with a discussion of the metamorphoses and destruction of Igneous rocks, which is to some extent a summary of questions touched upon in the body of the work. Dr. Hatch has contributed a glossary of terms used in describing rocks, for which also the student should be duly grateful, as its compilation must have cost much labour of a rather dull kind.

We have not attempted to give a full summary of this admirable work. Its 422 large octavo pages are so replete with valuable matter, that this would be impossible, and we have no disposition to save the student from the labour, no less profitable than pleasant, of reading the book. It is one which every geologist who desires accurate information on the structure of our igneous rocks should have upon his shelves. We have frankly ventured one or two small criticisms, but we wish it to be understood that these relate in the main to questions where, doubtless, the personal equation come in, with the reviewer as well as with the author—and conclude by no less frankly asserting that it bears on every page testimony of the most conscientious labour, and is not only a careful compilation, but also full of the results of original research. Knowing well Mr. Teall's abilities and learning, we had expected much, but we have found more. Henceforth he will hold a place in the foremost rank not only of petrographers but also of petrologists. T. G. B.

II.—Report on a Part of Northern Alberta, and Portions of Adjacent Districts of Assiniboia and Saskatchewan. By J. B. Tyrrell, B.A., F.G.S.; pp 1 E to 176 E, with Appendices i—iv and two Maps. (Geological and Natural History Survey of Canada, Part E, Annual Report for 1886; Montreal, 1887.)

In this report Mr Tyrrell furnishes us with an account of the geology and natural resources of the tract surveyed and points out the "extent, position and character" of its mineral deposits. The country traversed "lies between the 51st and 54th parallels of North latitude, from longitude 110° to 115° 15′ west, including an area of over 45,000 square miles." The author begins (p. 7 E) with a brief history of former explorations, among which the most important of the earlier ones was that carried out by Captain Palliser, with Dr. Hector as Geologist (1857-1859). These pioneer explorers were followed by many others, some of whom, like Milton and

Cheadle,[1] and W. F. Butler,[2] have made this vast region familiar to many readers by the graphic descriptions they have given of their journeyings through it; while Selwyn (1873), Ells (1875), and G. M. Dawson (1879) have added much to our knowledge of its geology. The physical features of the country are treated of in detail by Mr. Tyrrell (pp. 14 E to 56 E); but we have space only for a very brief extract from this part of his report. We learn that "the general character of the country is that of a sloping plain, breaking into abrupt ridges to the south-west, where a small area of foot-hills is included. From the base of these hills, which attain a height of 5000 feet above sea-level, the country declines to the north-east, sloping off from an altitude of 4000 feet, along the eastern edge of the foot-hills, to 1650 feet at Fort Pitt, on the Saskatchewan. The slope, though fairly regular, taken as a whole, is, however, broken by numerous high hills and deep river channels."

The rock formations dealt with in the report, under the head of "Descriptive Geology" (pp. 56 E to 126 E), are enumerated in the following table in descending order:—

	Feet.
POST-TERTIARY.	
Recent Deposits.—Sands, Clays, etc.	
Upper Boulder Clay.—Light-grey sand, and, generally, indistinctly stratified clay, with pebbles of gneiss, quartzite, etc.	
Lower Boulder Clay.—Dark-grey, thick-bedded, or massive, sandy clays, containing pebbles of quartzite, etc., and numerous fragments of lignite	
Pebble Bed.—Quartzite shingle, lying in a loose sandy matrix . .	
MIOCENE.	
Gravels, fine sands and argillaceous marls, the gravels sometimes cemented into a hard conglomerate	270
LARAMIE.	
a, *Paskapoo Series.*—Grey and brownish-weathering, lamellar or massive sandstones, and olive sandy shales; an exclusively fresh-water deposit	5700
b, *Edmonton Series.*—Soft whitish sandstones and white or grey, often arenaceous clays, with bands and nodules of clay ironstone, and numerous seams of lignite; a brackish-water deposit . . .	700
FOX HILL AND PIERRE.	
Brownish-weathering sandstones and dark-grey clay-shales . . .	600
BELLY RIVER SERIES.	
Soft, whitish sandstones and arenaceous clays, changing towards the east to light-brownish and yellowish sandstones and sandy shales, bottom not seen.	

"No intrusive rocks occur anywhere throughout the district, and below the top of the Laramie there is no evidence of any unconformity between the different formations. . . ."

Belly River Series.—Owing to the unfossiliferous character of the beds and the scarcity of sections, the exact boundaries of this series could not be accurately defined. The only fossils found were a few fresh-water genera, *Unio*, *Sphærium*, etc., and fragments of the leaves and wood of plants.[3] No workable coal-seams were found.

[1] "The North-West Passage by Land," 1863.
[2] "The Great Lone Land," 1873.
[3] Described by Sir W. Dawson in Trans. Roy. Soc. Canada, 1887, Sect. iv. p. 31.

Fox Hill and *Pierre Group.*—The Fox Hill sandstone and the Pierre shales were found to be so completely interbedded as to make it impossible to separate them, the yellow sandstone at the top of the group being precisely similar to that at the bottom, and holding, moreover, the same fossils, viz. *Placenticeras placenta*, *Teredo* burrows, etc. A large series of characteristic fossils was obtained, some of them being new to science.[1] No workable beds of coal were found within the district surveyed.

Edmonton Series.—This is regarded as the most characteristic series of the whole region, "for though its thickness, wherever determinable, was never found to exceed 700 feet, the horizontal position of the strata causes it to underlie a very large extent of country" from the outcrop of the "Big Coal Seam," on the North Saskatchewan, "to or a little beyond its easterly bend north of the Beaver Hills; and stretching a little south of east to Red Deer River in the vicinity of the Hand Hills, comprising the lower part of the bold escarpment, which there forms the south-western boundary of these hills." Extensive Coal-beds were found on this horizon, which, commencing as a "thin bed of carbonaceous shale, attained on the North Saskatchewan a thickness of 25 feet. Gold was found in paying quantities disseminated through the rocks in the vicinity of the "Big Coal Seam" on the North Saskatchewan. It is washed out of the sandstone and clays, and "settles with the heavier sand and gravel on the bars running out into the stream." Regarding the derivation of the gold in the Saskatchewan, it has been held[2] by Dr. Selwyn that it was not derived from the mountains at the source of that river, "but rather was washed out of the soft rocks which form its banks, after it leaves the harder strata of the mountains. . . ." (p. 134 E.)

The bottom of the Edmonton Series rests conformably upon the Pierre Shales, "without any sharp line of demarcation between the two," the shales gradually losing their massive character, and changing insensibly into thin beds, of brackish-water origin. Whereas in the Pierre group remains of land plants and animals were of rare occurrence, traces of land plants and fragments of the teeth and bones of Dinosaurs were met with in considerable abundance in the series under discussion. The last-named fossils were submitted to Professor Cope for determination. The rest of the fossils included Molluscs of the genera *Ostrea*, *Unio*, *Corbicula*, and *Panopea*, and plants consisting of *Trapa*, *Salisburia*, and *Carpolithes*, together with fragments of exogenous leaves and wood of *Sequoia* and *Thuja*.

Paskapoo Series.[3]—The author thus designates "all the Laramie rocks lying above those of the Edmonton series," and he therefore includes Dr. G. M. Dawson's "Porcupine Hills and Willow Creek series, and all but the lowest 700—900 feet of his St. Mary River

[1] These are described by J. F. Whiteaves in Appendix I. of the Report, p. 153 E.

[2] See Geol. Surv. Rep. for 1873-74, p. 58 (Montreal).

[3] From the "Blind Man," or "Paskapoo" River, which flows into the Red Deer River from the north-west, over rocks of the Paskapoo or upper subdivision of the Laramie.

series." Its thickness on Little Red Deer River was ascertained to be at least 5700 feet, "the bottom of the formation not being seen, and a considerable thickness having been probably removed from the top by denudation. The whole series was proved by its fossil fauna to be of freshwater origin, shells of the genera *Unio, Sphærium, Limnæa, Physa, Goniobasis*, etc., attesting this fact. Fossil plants of the genera *Sequoia, Taxodium, Platanus, Quercus, Populus, Salix, Viburnum*, etc., were also collected.

It will be observed in the table of strata above, that the Edmonton and the Paskapoo series are given as subdivisions of the Laramie, the former representing the Lower Laramie of the Canadian Geological surveyors, and the latter the Upper. The physical conditions under which these two series were deposited are thus described:—In the Edmonton series, which succeeds the marine beds of the Upper Cretaceous, Mr. Tyrrell finds abundant evidence of the brackish-water origin of this series, in the presence of beds of coal, fragments of land plants, and brackish water molluscs, besides numerous bones of Dinosaurs, "which have evidently been entombed in the beds over which they waded, or in the marsh on or along the edge of which they used to feed, or hunt their prey." He concludes, therefore, that this series "was laid down in shallow brackish water in an almost land-locked bay, or in a great salt marsh near the mouth of a large river. . . ."

"At the close of the Edmonton period, the pressure which had caused the uprising of the present plains-area from the bottom of the Pierre sea, and which towards the west had raised the land completely above the surface of the water, was relieved by the uplifting of the Rocky Mountains along a line near the western edge of this great area, and the "plains" sank again beneath the surface of the sea, now cut off entirely from the main ocean, and converted into a great inland lake, and a thickness of several thousand feet of sandstones and sandy shales was laid down on the gradually sinking floor; these sandstones and shales being the Paskapoo series of this report. . ."

No Dinosaurian remains were discovered in these beds, but a number of land plants, land and fresh-water molluscs, with occasional beds of coal occur in them.

The Laramie beds suffered a considerable amount of denudation at the close of their deposition, during a period of elevation which took place before the Miocene beds began to be laid down.

From all these facts Mr. Tyrrell deems himself justified in concluding that the Cretaceous Epoch terminated with the deposition of the uppermost beds of the Edmonton series; and that the Tertiary Epoch began with the commencement of the Paskapoo period, which he regards as "the representative of the Eocene of Europe," an opinion held also by Dr. Newberry.[1]

Concerning the exact age of the Laramie little can be affirmed with certainty. We have seen what Mr. Tyrrell's views are upon the subject; it may be profitable now to consider those of some

[1] Trans. New York Academy, Feb. 1886.

other geologists. The question has been attacked with much ability and mastery of details by Mr. Lester F. Ward, in a "Synopsis of the Flora of the Laramie Group."[1] This writer gives it as his opinion that "it is wholly immaterial whether we call the Laramie Cretaceous or Tertiary, so long as we correctly understand its relations to the beds below and above it. We know that the strata immediately beneath are recognized Upper Cretaceous, and we equally know that the strata above are recognized Lower Tertiary. Whether this great intermediate deposit be known as Cretaceous or Tertiary is therefore merely a question of a name, and its decision one way or another cannot advance our knowledge in the least." Sir William Dawson, in his memoir on the "Fossil Plants of the Laramie Formation of Canada,"[2] concludes "that we must either regard the Laramie as a transition Cretaceo-Eocene group, or must institute our line of separation in the Middle Laramie division, which has, however, as yet afforded no fossil plants."

Miocene.—"Resting on the denuded edges of the Laramie in the Hand Hills, are beds of light-grey argillaceous marls inter-bedded with fine grained sands, which pass upwards into a bed of quartzite pebbles, in some places held together by a hard calcareous cement, and forming a compact conglomerate."

No fossils were found in this formation, but from its position and character it was judged to be of the same age as the Miocene of the Cypress Hills, described by Mr. McConnell in 1884.[3]

Post-Tertiary.—The following are the subdivisions of this formation, distinguished by Dr. G. M. Dawson, which hold good also in the area explored by Mr. Tyrrell:—"Stratified sands, gravels and silts. Upper boulder-clay. Interglacial deposit with peat. Lower boulder-clay. Quartzite shingle and associated beds."

These beds overlie the greater part of the region examined in "an extensive, though generally thin, sheet," filling up the irregularities in the surface of the Cretaceous and Laramie rocks, and forming also many of the rolling hills.

Economic Minerals.—First in importance are the extensive deposits of Coal and Lignite which underlie an area of more than 12,000 square miles in the western part of the district surveyed. Of bituminous coal, a seam near the Bow River is estimated to contain about 9,500,000 tons of coal to the square mile. Of the lignitic or semi-bituminous coals, the seam on the North Saskatchewan River was computed to contain over 150,000,000 tons. The occurrence of Gold in this river has already been noted.

This valuable report closes with four appendices, the first containing descriptions by J. F. Whiteaves of the fossils collected by Mr. Tyrrell (1885 and 1886) in the Cretaceous and Laramie Rocks; the second, "Lists of Lepidoptera," by Mr. James Fletcher; the third, "List of Elevations"; the fourth, "Cree and Stoney Indian names for places within the area of the accompanying map." It

[1] Sixth Annual Rep. of the United States Geol. Surv. 1884—85, Washington, 1885.
[2] Trans. Roy. Soc. Canada, Sect. iv. 1886, p. 19.
[3] Geol. Surv. Rep. Canada, for 1882—84, p. 140 C.

may be added that the maps accompanying the Report are drawn to a scale of seven geographical miles to one inch. One illustrates the geology, the other marks the wooded and prairie tracts of the country embraced in the report. A. H. F.

III.—Dr. Georg Baur on Fossil Chelonia.

THE publication of preliminary notes and synopses of results is often desirable, as affording the opportunity of criticism before the completion of any extensive work; and it is sometimes a convenient method of securing valuable co-operation from other workers in a given field. But when indulged in to so great an extent as is now unfortunately the custom in some quarters, the practice becomes both confusing and annoying; and the steady progress of science degenerates into a mere struggle for "priority," burdened with endless unfinished notes and crude speculations. Such considerations are once more suggested by Dr. Georg Baur's latest remarks upon the Palæontology of the Chelonia. Entombed in the form of a footnote to a four-page pamphlet upon the origin of the paddles of the Ichthyopterygia,[1] is the definition of a supposed new genus of Chelonia from the Keuper Sandstone of Würtemberg! The fact is one of considerable interest, and the fossil of the greatest importance; but the future historian of the Chelonia is hardly to be blamed if he fails to discover the "priority" of the name *Proganochelys Quenstedtii*, when referring to this unique fossil: one author, indeed, in another "preliminary note" upon the same specimen,[2] has already overlooked both the description and the name. The fossil is a natural internal mould of the carapace and plastron of a Chelonian, especially remarkable for its high degree of specialization; and it is not improbable that, when more is known of the animal, it will prove to be identical with *Chelytherium obscurum*, von Meyer. The plastron is described as completely closed, and united laterally with the carapace, without any fontanelles.

The next reference to *Proganochelys* occurs in a letter[3] announcing the discovery of small dermal ossicles upon the limbs of *Testudo Leithii*, where the interest of the genus is remarked upon in connection with the controversy as to the systematic position of the Athecan Chelonia: and then the subject of "Unusual Dermal Ossifications" suddenly develops into the definition of another new genus, founded upon the well-known "*Chelone*" *Hoffmanni* of the Maastricht Chalk. Dr. Baur proposes henceforth to place the latter in a genus named *Allopleuron*, on account of the small development of the costal plates and the narrowness of the marginals. The results are most interesting and worthy of consideration, but it is not too much to ask that in future we may have the subjects under recognizable titles, even if it is still considered desirable to publish them in so obscure and scattered a form. A. S. W.

[1] G. Baur, "Ueber den Ursprung der Extremitäten der Ichthyopterygia," Bericht xx. Versamml. Oberrhein. geol. Vereins, 1887.

[2] Zarszewski, "Eine im Stubensandstein des Keupers gefundene Schildkröte," Württ. Jahresh. 1888, p. 38.

[3] G. Baur, "Unusual Dermal Ossifications," Science, March 23rd, 1888 (vol. xi. p. 144).

IV.—On the Structure and Relations of *Edestus*, with a Description of a Gigantic New Species. By Prof. J. S. Newberry, M.D. (Annals New York Acad. Sci. vol. iv. No. 4 (1888), pp. 1-10, pls. iv.-vi.)

THE discovery of a new gigantic example of the remarkable fossil spine, *Edestus*, in the Coal Measures of Mason County, Illinois, affords Prof. Newberry the opportunity of again reviewing the characters and possible relationships of this anomalous fish-fragment. The memoir is one of much interest, and refers to nearly all the points hitherto ascertained, except Trautschold's discovery of the occurrence of the fossil in Russia. It would, however, have added much to the completeness of the discussion, if a microscopical section had been prepared; for if *Edestus* consists of "dense bone" (p. 5), it is certainly not a Selachian dermal appendage, and if it has the well-known structure of the latter, it is useless to speculate as to its pertaining to a Ganoid (p. 4). From various other considerations, Prof. Newberry concludes that the original fish must have been a Selachian; and the fossil is regarded as an undoubted spine. The latter must have been "buried in the integuments throughout its entire length; the enamelled denticles alone projecting above the surface to form a saw, which would be a terrible weapon, if placed upon some flexible portion of the body where it could be used with freedom and power. The extremity of the spine may have lain in a sheath from which it could be partially erected by muscular action, and used as the lancet of the surgeon fish (*Acanthurus*) is; but the bilateral symmetry of *Edestus* proves that if employed in this manner it must have been located on the upper margin of the tail or back." The arrangement is considered to be best explained—perhaps precisely paralleled—by *Trygon*, in which "a considerable number, sometimes five or six, defensive spines are set in the place of the posterior dorsal fin. They come into use in succession, like the fangs of venomous serpents. As the anterior one loses its denticles or becomes worn or broken, it falls, and is succeeded by another *from behind*. Yet several may be in existence and effective at the same time, all arising from a common segmented bony base which grows by additions to its posterior extremity." The new spine of *Edestus giganteus* is at least 18 inches in length, by 7½ inches in breadth, and indicates the enormous dimensions to which the fish must have attained, if this ingenious explanation proves true. A. S. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 6, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. The following letter from H.M. Secretary of State for India accompanying some specimens of rubies in the matrix from Burmah:—

"India Office, Whitehall, S.W., 2nd June, 1888.—Sir,—I am directed by the Secretary of State for India in Council to present to

the Geological Society some specimens of Burmese rubies attached to their matrix, which were procured by Mr. Barrington Brown, at present employed by Government in examining the mines which came into their possession on the annexation of Upper Burmah."—Mr. Barrington Brown writes concerning these specimens thus:—'I send . . six specimens of rubies in granular limestone, where they were formed. They were obtained by blasting, under my direction, in a place formerly mined by natives. . . . As I believe the fact of the ruby being traced to its matrix is new to science, the specimens may prove of interest to scientific men. . . . I should like Professor Judd, President of the Geological Society, to see the specimens.'—I am, Sir, your obedient servant (signed) J. A. Godley.—President, Geological Society."

2. "On the Sudbury Copper Deposits (Canada)." By J. H. Collins, Esq., F.G.S.

These deposits occur in Huronian rocks. The author described two exposures, known as Copper Cliff and Stobie, about 8 miles apart. At the former the ore was found in the face of a cliff of diorite about 40 ft. high.

The ore exists in three distinct forms:—

1. As local impregnations of siliceous and felspathic beds of clastic origin, in the form of patches and strings of cupreous pyrrhotite.

2. As contact-deposits of the same material lying between the impregnated beds and large masses of diorite.

3. As segregated veins of chalcopyrite and of nickeliferous pyrrhotite, filling fissures and shrinkage-cracks in the ore masses of the second class.

The author considered the first as original, or of high antiquity; whilst the two latter are due to segregation produced either by intrusion of diorite, or by internal movements. He compared these deposits with those of Rio Tinto of Devonian age, showing their similarities and differences. At the latter place the intrusive masses are quartz-porphyries, and the metallic deposits consist mainly of bisulphide of iron. The ore-bodies in the Canadian deposits are not so large. From the cupreous pyrrhotite of Sudbury, rich though it be, compared with the Rio Tinto ore, the copper cannot be so cheaply extracted by the wet method, and the ore is of no avail as a source of sulphur. Nickel is everywhere present in the cupreous pyrrhotite of Sudbury, and of no advantage to the smelter. The differences above recorded are probably not due to differences in the containing rocks, since similar differences may be noticed in the pyritous deposits of Canada, where the country rocks are identical.

3. "Notes on some of the Auriferous Tracts of Mysore Province, Southern India." By George Attwood, Esq., F.G.S., F.C.S., etc.

The author was employed during parts of 1886-7 in inspecting a large area of mineral lands in Southern India supposed to be auriferous, and the paper contained the results of his observations.

1. *Melkote Section.*—This section (in the Hassan district of the province of Mysore), starting one mile west of Melkote in a north-easterly direction, exposed gneiss, mica-schist, hornblende-schist,

quartzite, talc- and chlorite-schists, eclogite, and quartz veins, striking generally N. 20° E., and having varying dips. The eclogite was described at length, and special attention was called to the flattening of the contained garnets, which were probably originally almandite; other evidences of great crushing were also noted.

In this section and on most of the schistose lands of Mysore a dull grey, nodular, and botryoidal calcareous deposit, known as "kunkur," is found in nullahs, on hill-sides, and on the detritus of old gold washings, and it was suggested that the contained lime was derived in great measure from hornblende-schists.

Many quartz outcrops, large at the surface but diminishing in thickness downwards, were met with at the east end of the section; these veins have a strike about N. 15° E. to N. 20° E., coincident with that of the schists.

Extensive gold-washings have been carried on in the ravines and hill-sides, and the mode of occurrence and character of the gold were described.

The author considered the schists, as well as the quartz veins, to belong to very old series of rocks, probably Archæan.

2. *Seringapatam Section.*—The second section was taken in a south-easterly direction from the 72nd milestone on the Seringapatam and Bangalore road to the N.W. side of the village of Arakere. Gneiss, hornblende, and mica-schists, etc., were here met with, striking about N. 20° E. with varying dips. These were traversed by auriferous quartz-veins which had been largely worked, and the author gave a description of the former methods of extracting the gold.

At the S.E. end of the section the schists were found to be much broken by porphyrite dykes of much more recent origin, most likely of Tertiary age. A small granite dyke intersected the Elliot Lode diagonally, and was considered to be of Upper Tertiary age.

3. *General Observations.*—The author described the results of traverses of other districts; he pointed out the evidences of great pressure which had broken up the gneissic rocks and compressed the schists, and conjectured that this might have been produced by the gradual rise of the Eastern and Western Ghats, and finally called attention to the great denudation which the Mysore plateau had undergone.

An Appendix by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., gave an account of the microscopic characters of the schists, the flattened garnets, the porphyrites, etc., and in this it was pointed out that one set of rocks belonged to an ancient series which, even if wholly or in part of igneous origin, assumed their present mineral structure and condition at an epoch remote from the present, whilst another set was certainly igneous and of more recent date.

4. "On the Durham Salt-district." By E. Wilson, Esq., F.G.S.

In this paper the author described the new salt-field in the North of England, occupying the low-lying country bordering the estuary of the Tees, and situated partly in Yorkshire and partly in Durham.

The history of the rise and progress of the salt-industry in South

Durham was given, since the first discovery of salt by Messrs. Bolckow, Vaughan & Co. at Middlesboro', in the year 1859.

The stratigraphical position of the saliferous rocks of the Durham salt-district was considered in some detail. The diverse views which have been previously expressed on this head were referred to, and reasons given for concluding that all the beds of rock-salt which have been hitherto proved in this field, and the red rocks with which they are associated, belong to the upper portion of the Trias, viz. to the Upper Keuper series (Waterstones subdivision).

The probable area of this salt-field, the limits of the distribution and varying depths of the chief bed of rock-salt, were indicated, and the extent of its supplies pointed out.

In conclusion, the author called attention to the waste, as well as to certain other disadvantages resulting from the process of winning the salt now in operation.

5. "On the Occurrence of *Calcisphæræ*, Williamson, in the Carboniferous Limestone of Gloucestershire." By E. Wethered, Esq., F.G.S., F.C.S.

The small hollow spheres, with varying forms of peripheral appendages, described by Prof. Williamson as *Calcisphæræ*, were found in the Carboniferous Limestone of Flintshire, and were suggested by him to be possibly Foraminifera or the reproductive capsules of some marine form of vegetation, although he admitted that no forms hitherto discovered afforded any definite support to this hypothesis. Prof. Judd expressed a belief that the objects were Radiolaria; whilst Mr. Shrubsole discovered similar bodies in the Mountain Limestone near Llangollen, and conjectured that the described forms included both Foraminifera and Radiolaria.

The author has discovered the *Calcisphæræ* in great numbers in the Carboniferous Limestone of Gloucestershire. He discussed the identity of certain calcareous rings ·005 in. in diameter, seen in sections of the limestone of Clifton, etc., with siliceous bodies which he had described in a recent paper read before the Society, and gave an account of the calcareous and siliceous forms which were both referable to *Calcisphæræ*. He commented upon the character of the carbonate of lime of the calcareous bodies, which presented a granular structure characteristic of the truly organic portion of the limestone, and not a clear crystalline aspect like that of the infilling or replacing calcite; he concluded therefore that the tests had been originally calcareous, and not siliceous replaced subsequently by carbonate of lime. This was urged as a strong argument against regarding the organisms as Radiolaria, and the author, whilst considering it unwise to come to a decided conclusion, believed it safe to say that they were Protozoa.

6. "Second Note on the Movement of Scree-material." By C. Davison, Esq., M.A. Communicated by Prof. T. G. Bonney, D.Sc., F.R.S., F.G.S.

After briefly recapitulating the substance of his previous paper, the author now communicated the results of experiments continued for a year. He gave a figure in which a continuous line represented,

in millimetres, the movements of the upper stone from week to week, whilst a contiguous dotted line indicated the mean ranges of temperature. The rate of descent does not depend solely on the mean range. He gave the following comparison of rates of descent :—

	Average daily range of temperature.	Total mean descent in millim.	Rate of descent in inches per day.
Summer, 184 days.....	14°·4 F	8	·00171
Winter, 182 days	8°·0	$5\frac{1}{6}$	·00121

Thus the changes are not altogether proportional to the ranges of temperature, being relatively higher in the winter months. In considering the influence of rain, he observed that its effects are to slightly increase the rate of descent by diminishing the coefficient of friction, and by lowering the temperature, both as being itself generally colder than the air on the ground surface, and also owing to evaporation. He likewise observed that the rate of descent was nearly doubled during the latter part of the winter, chiefly owing to the effects of snow.

II.—June 20, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read :—

1. "On the Occurrence of Marine Fossils in the Coal-measures of Fife." By James W. Kirkby, Esq. Communicated by Prof. T. Rupert Jones, F.R.S., F.G.S.

This paper recorded the discovery of fossils of good marine types in the Fifeshire Coal-measures. This coal-field is of limited extent, the Coal-measures dipping under the sea towards the east and south. The prevailing fossils are those characteristic of the Coal-measures in other districts, *Anthracosia*, *Anthracomya*, *Anthracoptera*, *Spirorbis*, many fishes, and some few Amphibian remains. Lately a sinking was commenced in the Upper Red beds, below which, and just above a thin band of poor coal, a thick bed of dark shale was passed through, which proved to be tolerably fossiliferous. *Lingula*, *Murchisonia*, and two species of *Bellerophon* occurred. This horizon was subsequently proved elsewhere in the district, and furnished the following fossils from three localities, namely :—*Strephodus sauroides*? Ag. (teeth and scales); *Rhizodopsis*, sp. (scales); Palæoniscid scales; *Diplodus gibbosus*, Ag.; *Mesodomodus*, sp. n.; *Petalodus Hastingsiæ*; *Discites rotifer*? Salt.; *Discites*, sp. (with longitudinal ribs); *Discites*, sp. (smooth); *Orthoceras attenuatum*? Flem.; *Bellerophon Urii*, Flem.; *Murchisonia* (*Aclisma*) *striatula*, De Kon.; *Sanguinolites*, sp.; *Productus semireticulatus*, var. *Martini*, Sow.; *Discina nitida*, Phill.; *Lingula mytiloides*, Sow.; *Lingula squamiformis*; Crinoid stems (*Actinocrinus*?); Plant-remains (obscure).

Reference was then made to the occurrence of similar fossils in the same formation elsewhere, and particularly in the West of Scotland, North of England, and Lancashire. The author concluded, from the frequency of the beds containing true marine remains, that the Coal-measures were formed in low-lying areas; and that, when the land was slightly depressed, at times the waters of the sea had

access to such spots, bringing back species of shells and Crinoids that had existed in the Carboniferous-Limestone ocean of an earlier period. Some further remarks were made on the peculiar nature of the ordinary fauna of the Coal-measures; and the author observed, in conclusion, that no marine deposits have been observed as yet in the Upper Red beds (d^{51}) of the Fife or other Scotch Coal-measures.

2. "Directions of Ice-flow in the North of Ireland, as determined by the Observations of the Geological Survey." By J. R. Kilroe, Esq. Communicated by Prof. E. Hull, F.R.S., F.G.S.

While the striæ S.E. of a line drawn from Strangford Lough to Galway Bay all trend in one direction, two sets of striæ occur N.W. of that line, which are generally at right angles to each other, and are frequently seen upon the same rock-surface. The direction of one of these is N. by W. in Antrim and Londonderry; N.W. over the highlands of Fermanagh; and N.E., N., and N. by W. in Donegal, etc. That of the second set is W. 25° S., swinging round to W. in Donegal and S.W. towards Galway Bay, and is strikingly persistent throughout. A few striations occur which do not conform to these directions, and are attributable to local ice-flows.

The second set of striations was referred to the ice of the *Scottish Glacial System*, and evidence was cited from the researches of Messrs. Symes and M'Henry, Dr. Geikie, and others in support of this view, which is confirmed by the relative positions of the boulders and their parent rocks. Striæ bearing westward have been observed at a height of 1100 feet in county Mayo.

The effects of the *Irish Glacial System* have been considered by the Rev. M. Close, Mr. G. H. Kinahan, and Prof. Hull. Striations occur up to 1340 feet in Donegal. The ice of this system flowed in a general S.E. direction to the S. of the axis.

With regard to the relative age of the two sets of striæ, it is observable that those bearing northward are by far the most numerous; so that, although it is reasonable to suppose that a considerable accumulation of snow and ice obtained in the Irish area whilst the Scotch system was gathering its maximum strength, the striations produced by this gathering would be largely effaced by the westward-flowing Scotch ice; and that, after the decline of the latter, an independent Irish *Mer de glace* flowed northward and southward, finding its axis of movement in the great central snow-field.

3. "Evidence of Ice-Action in Carboniferous Times." By John Spencer, Esq., F.G.S.

The author combated the notion that there is any *à priori* improbability in the action of ice during the period in question. In the case under consideration, of the two agents, land-ice or floating-ice, he was inclined to adopt the latter, as having been the cause of the phenomena he described. The bed affected is the Haslingden Flag-rock, a member of the Millstone-Grit series, which is directly covered by a shale of the same series. The surface of this Flag-rock is largely striated, the striæ having a N.E. and S.W. direction, and being nearly parallel. The area exposed is 200 square feet. The Flag-rock dips to the east at an angle of 30°; but there seems no possibility

of these striæ having been produced by landslips or local disturbance. A quarry on the same horizon, near Rochdale, exhibits similar phenomena. As collateral evidence of ice-action, he alluded to the boulders frequently found in the coal-seams.

4. "The Greensand Bed at the Base of the Thanet Sand." By Miss Margaret I. Gardiner, Bathurst Student, Newnham College, Cambridge. Communicated by J. J. H. Teall, Esq., M.A., F.G.S.

This bed may be seen between Pegwell Bay on the east and Chislehurst on the west, and a somewhat similar bed occurs at Sudbury, Suffolk. An examination of the Kentish layer showed it to consist of 45 per cent. of quartz, 15 per cent. of glauconite, and 40 per cent. of flint. Amongst the rarer minerals are felspar, magnetite, spinel, zircon, garnet, rutile, tourmaline, actinolite, epidote, and chalcedony; and there are a few microscopic organisms, either Radiolarians or Diatoms, and some Foraminiferal casts.

The Sudbury Greensand has 75 per cent. of its grains consisting of glauconite, and of the quartz- and flint-grains only 10 per cent. are flint; several of the rarer minerals found in Kent occur here also.

The large flint-percentage in the Kentish grains was alluded to in support of the existence of an unconformity at the base of the Tertiary deposits of that area; and the relatively small percentage of flint in the sands now being formed along a very similarly situated shore was suggested to be due to the drifting débris derived from the coasts composed of Tertiary and Wealden rocks, which became mixed with the material brought down by the Thames.

5. "On the Occurrence of *Elephas meridionalis* at Dewlish, Dorset. By the Rev. O. Fisher, M.A., F.G.S.

The author's attention was first drawn to this subject on seeing two molars of an elephant in the Blackmore Museum labelled "Dewlish, Dorset." He at once attributed them to *E. meridionalis*. Subsequently he ascertained that they were part of a find made in 1813 by a Mr. Hall. Dr. Falconer, from rubbings, attributed the teeth to *E. antiquus*; and Dr. Leith-Adams would not allow that they belonged to *E. meridionalis*, because that species had never been found so far west. Last year the author and Mr. Mansel-Pleydell went to Dewlish, and the latter has since continued the workings. The remains have been found high up on the face of a steep chalk scarp facing west, 10 feet below the brow and 90 feet above the existing stream, in such a position as to suggest that the deposit was the result of an undercut of the stream when it flowed at a higher level. It probably lies in the prolongation of a line of fault with a deviation to the east. The following section was given:—

	ft.	in.
1. Chalk rubble	0	10
2. Fine sand and flints, with elephant remains	3	0
3. Sand and ferruginous gravel...		?
4. Flint-material, waterworn		?
5. Sand, the lower portion with different-sized flints ...		?

There were no shells or Microzoa.

The author speculated on the probable lapse of time, and on the importance of the discovery of *E. meridionalis*, a pre-glacial mammal, so far west. A list of the bones found was given.

6. "On Perlitic Felsites, probably of Archæan Age, from the Flanks of the Herefordshire Beacon, and on the Possible Origin of some Epidosites." By Frank Rutley, Esq., F.G.S.

The author has previously described a rock from this locality in which faint indications of a perlitic structure were discernible. In the present paper additional instances were enumerated and a description was given. The perlitic structure is difficult to recognize, owing to subsequent alteration of the rock.

Decomposition-products, apparently chiefly epidote, with possibly a little kaolin, have been found in great part within the minute fissures and perlitic cracks.

The author suggested, from his observations, that felsites, resulting from the devitrification of obsidian, quartz-felsites, aplites, etc., may, by the decomposition of the felspathic constituents, pass, in the first instance, into rocks composed essentially of quartz and kaolin; and that, by subsequent alteration of the kaolin by the action of water charged with bicarbonate of lime and more or less carbonate of iron in solution, these may eventually be converted into epidosites.

He regarded it as probable that the rocks are of later Archæan or Cambrian age.

7. "The Ejected Blocks of Monte Somma," Part 1, Stratified Limestones." By H. J. Johnston-Lavis, M.D., F.G.S.

Introductory.—The author referred to the Hamilton collection, now in the British Museum, and to the work of Prof. Scacchi, who enumerated 52 mineral species as having been found in the ejected blocks, and indicated the importance of these from a geological and volcanological point of view. His own collection contains over 600 specimens, showing the graduation from unaltered limestones, through various stages of change into numerous varieties of "true metamorphic rocks," which, in their turn, shade into igneous rocks more and more approaching the several modifications of the normal cooled magma of the volcano. Moreover, such rocks come from depths where they have not been affected by alterations of a secondary nature.

He then gave a classification of the varieties of ejected blocks. The Tertiary rocks are but slightly metamorphosed, whilst the limestones of Cretaceous or earlier age afford an almost unlimited series of mineral aggregates. Physical changes have converted them into carbonaceous and saccharoidal marbles; next oxides and aluminates have separated, and silicates have been introduced. Such rocks come under the definition of *accidental* ejectamenta. They are only ejected when the apex of the crater-cavity, formed by an explosive eruption, extends below the platform of the volcano into the underlying rocks. He then traced the history of the eruptions of Somma-Vesuvius through divers phases, showing that it was only at a comparatively late period that limestone-fragments were blown out, though this had taken place long before the Plinian eruption. The stratified limestones have been chosen for the first part of this paper, because their original lithological structure acts as a guide as we proceed from a normal limestone to its extreme modifications.

Part I.—The character of the limestones which underlie the platform of Vesuvius may be studied in the peninsula of Sorrento, where the mass attains a thickness of 4700 feet. They are magnesian in varying proportions. A table was given showing twenty-seven analyses, made principally by Ricciardi, the amount of MgO ranging from 1 to 22 per cent. Silica rarely exceeds 2 or 3 per cent., whereas in the greater number of limestones it is absent. The bituminous matter, though a powerful colouring agent, usually exists in quantities too small for estimation, but sometimes reaches 3 per cent. Such are the materials out of which the extraordinary series of silicate-compounds have been developed, and as these materials of themselves could not form peridotes, micas, pyroxenes, etc., it is clear that the silica, alumina, iron, fluorine, etc., must have been introduced from without, viz. from the neighbouring igneous magma. The author then discussed the question of the probable methods, being inclined to favour the notion of vapour in combination with acid gases.

The bulk of the paper was occupied with a detailed description of the microscopic structure of these stratified limestones and their derivatives. The author remarked that the same metamorphic changes may be traced on a much grander scale amongst the ejected blocks, and hinted at the similarity of these changes to those of contact-phenomena as seen elsewhere, and even of regional metamorphism, the two main factors to be considered being the composition of the rock to be acted upon and that of the magma acting.

The changes which ensue in an impure limestone are, in the first place, the carbonization of the bituminous contents, which are converted into graphite; and a kind of recrystallization, approaching the saccharoidal structure, seems to have taken place, although the stratification, etc., is preserved. A few grains of peridote now begin to make their appearance, chiefly as inclusions within the calcite crystals, and thus by degrees the results already recorded are effected. In the early stages only is the metamorphism selective. The order in which the new minerals seem to develope is the following:—(1) Peridote, Periclase, Humite. (2) Spinel, Mica, Fluorite, Galena, Pyrites, Wollastonite. (3) Garnet, Idocrase, Nepheline, Sodalite, Felspar. Many of these minerals are crowded with microliths, which there is reason to believe consist of pyroxene.

CORRESPONDENCE.

ELEVATION AND SUBSIDENCE.

Sir,—In the suggestion as to the cause of subsidence and elevation put forward by Professor Lloyd Morgan,[1] it is not quite clear whether on his hypothesis he looks upon the conversion of molten rock into the crystalline condition as a case of simple condensation by pressure following ordinary lavas, or whether he assumes that after a certain pressure is applied the molten rock will suddenly assume the crystalline condition and contract, and thereby cause

[1] Geol. Mag. July, 1888, pp. 291–97.

subsidence. For the proper estimation of the efficiency of the cause invoked, it is requisite that this should be clearly set forth. That lateral displacement by weight of accumulated sediment together with actual compression of the rocks below may take place in certain cases is extremely probable.

The assumption of the existence of a zone of molten rock at a certain distance below the surface of the earth in so sensitive a condition as to respond to the weight of accumulation by becoming solid or that of denudation by becoming liquid is rather a large one, especially when the physical part is unsupported by experiment or quantitative determination. If these were supplied, it would be a fit subject for investigation, but the suggestion fails as a general explanation of subsidence and elevation, even if the assumptions are admitted, inasmuch as it does not account for the elevation of areas of former great sedimentation, which is one of the most striking facts of geology.

T. Mellard Reade.

THE NOMENCLATURE OF AMMONITES.

Sir,—I had not much hope of converting Mr. Buckman from what, in common with Mr. Haddow, I conceive to be the error of his ways; but I wished to protest against the system of which he is an exponent.

He still assumes that *Ægoceras* and *Arietites* are *genera*, which is exactly what I ventured to question. He says I do not attempt to discuss *Lioceras*, but I should have thought he would understand that it could be treated in the same way as *Harpoceras* (if it is a group of equal value). Let us write in catalogues *Ammonites* (*Lioceras*) *elegans*; specialists will doubtless prefer to call it *Lioceras elegans*; but most geologists will probably be content with *Ammonites elegans*, regarding *Lioceras* merely as a subgeneric name.

My chief point, which Mr. Buckman entirely fails to notice, is this, that if the specialists rank *Harpoceras*, *Lioceras*, etc., as genera, each of them may be accredited with a species having the same specific name. Fancy half a dozen different *Amm. elegans* referable to an equal number of these so-called genera.

A. J. Jukes-Browne.

"GEOLOGY FOR ALL."

Sir,—While thanking you for your notice of "Geology for All," perhaps you will permit me to say that what is called a "slip" is explained by the context, and is in accord with the spirit and intention of the book, while the high per-centage of silica in orthoclase is duly acknowledged on page 58, where the fact is wanted.

I may add that my aim was to find a new and intermediate path between the two old and well-beaten ones of Academic or Text-book geology and so-called "popular" or entertaining geology, neither of which in my humble opinion is likely to lead to the end I have in view, namely, a general knowledge of geology by all well-educated people. In the days of Buckland and Hugh Miller, fossils were

marvels, and these certainly attracted much attention to geology. Now they are no longer so, and from my experience, and it is not a small one, they and their nomenclature do much to restrict a knowledge of the great teachings of geology to the limited circle to which your reviewer so justly refers.

J. Logan Lobley.

City of London College,
July 16th, 1888.

MISCELLANEOUS.

Geological Survey of England and Wales.

We are informed that Mr. H. W. Bristow, F.R.S., has retired from the Directorship of the Geological Survey of England and Wales, after a lengthened service of forty-six years. Joining the staff of the Survey in 1842, under De la Beche, he commenced field-work in the Silurian regions of Radnorshire, and subsequently surveyed large areas of the Secondary and Tertiary strata, more especially in Somerset, Dorset, Hampshire, the Isle of Wight, and Sussex. This work has formed the basis for all later and more minute observations on the strata. The history of the Survey with which Mr. Bristow has been so long associated has been told in part in the Memoirs of Edward Forbes and Murchison by the present Director-General, and also in the Letters of Jukes; and it is pleasant to read of the early labours of the small yet enthusiastic band of geologists, who numbered only 10 in 1844; but these included Ramsay, Warington Smyth, John Phillips, Aveline, W. H. Baily, and Edward Forbes. In the genial company of Forbes, Mr. Bristow carried on much of his detailed work in the Isles of Wight and Purbeck; and we understand that a new edition of Mr. Bristow's Memoir on the Isle of Wight will shortly be published. Until 1872, when he was appointed Director, Mr. Bristow was more or less actively employed in the field, devoting especial attention in these later years to the Rhætic or Penarth Beds—the latter name being given by him on account of the prominent exposures of these strata on the Glamorganshire coast.

We learn that Mr. H. H. Howell, F.G.S., Director of the Geological Survey of Scotland, now undertakes the additional duties of Director for England and Wales, and his excellent geological work in the Midland counties, the North of England, and the South of Scotland, together with his well-known administrative capacity, will cause the appointment to be hailed with satisfaction.

We have also much pleasure in announcing that Mr. J. J. H. Teall, M.A., F.G.S., has recently joined the staff, and is specially charged with the study of the crystalline schists and the problems of regional metamorphism.